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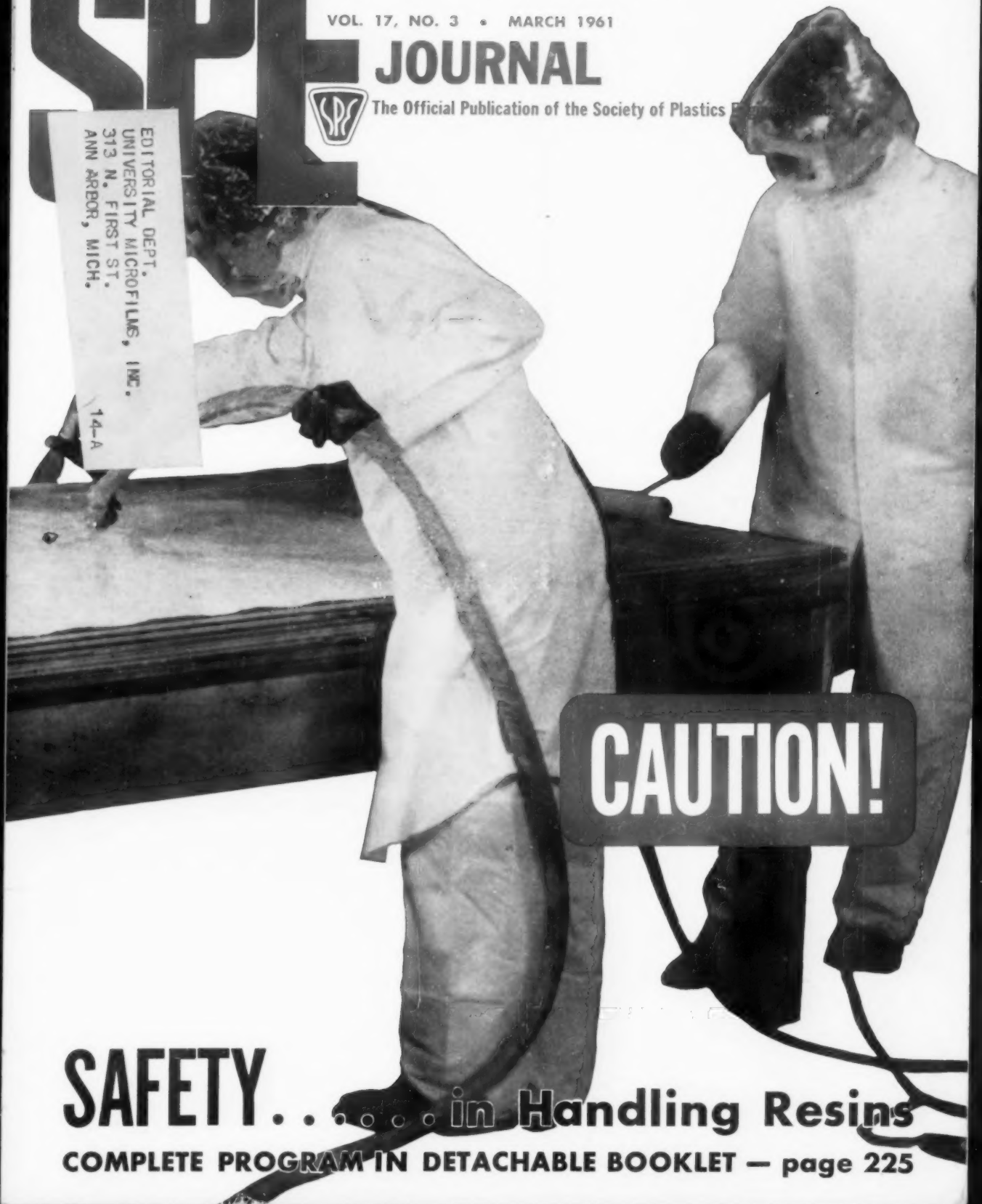

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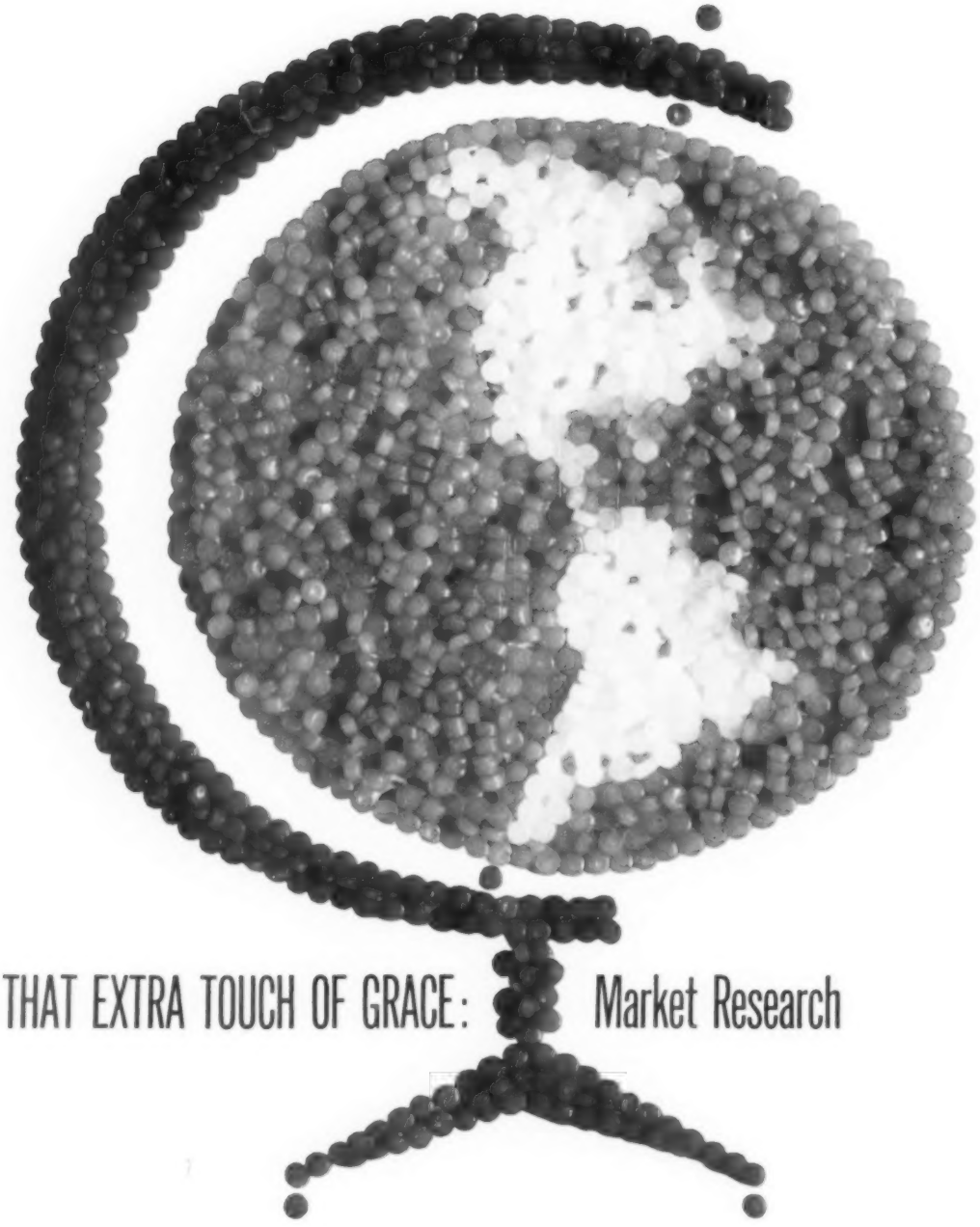

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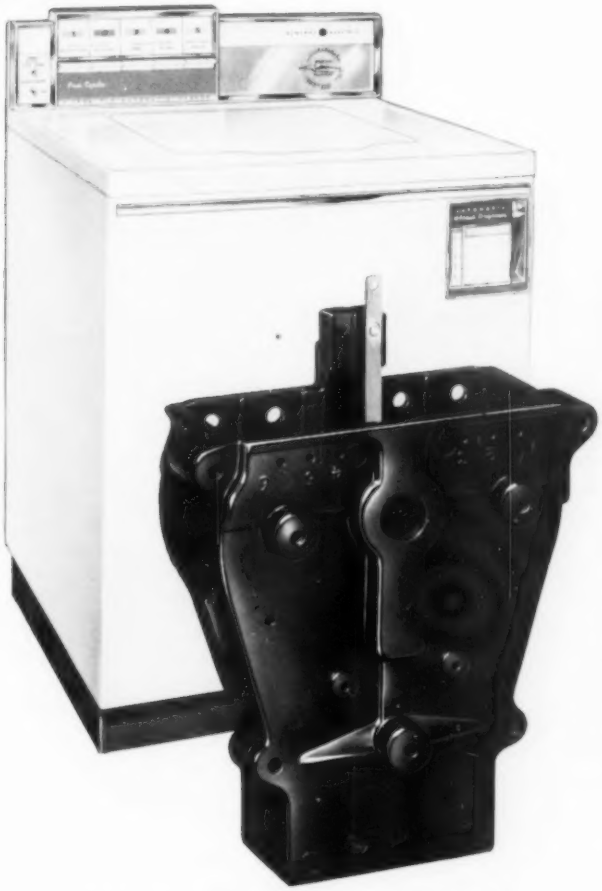

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SPE JOURNAL

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COVER: Dramatic photograph shows the use of safety clothing in processing an epoxy-glass system. For a complete safety program for handling liquid thermosetting resins, see page 225. *(Cover photograph courtesy Union Carbide Plastics Co.)*

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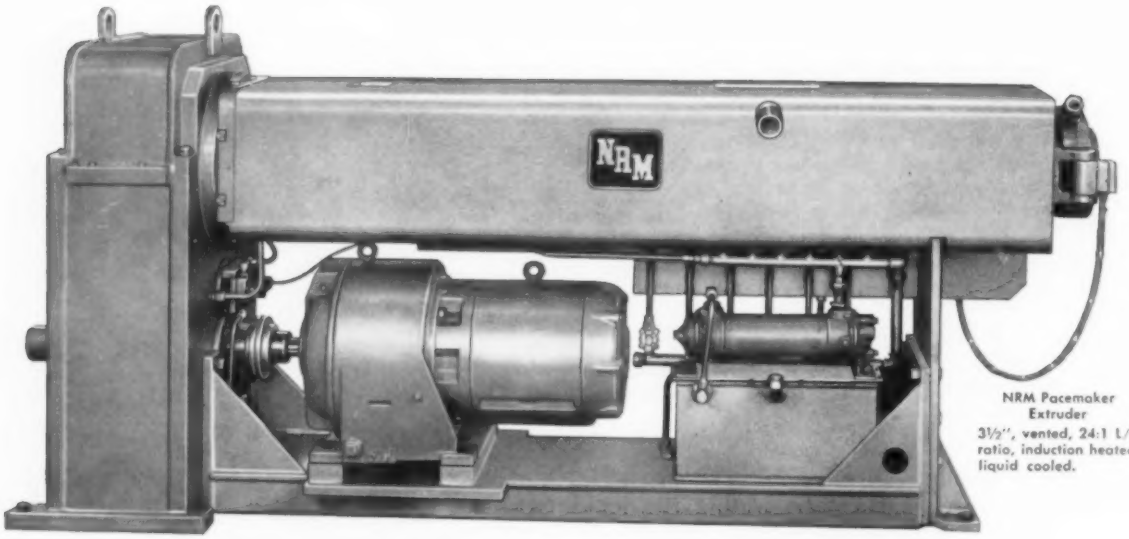

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EDITORIAL

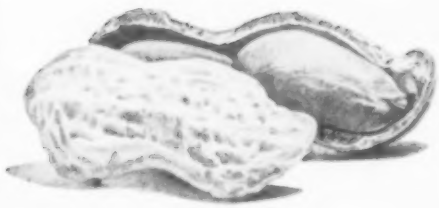
Plastics and Stuff . . .

Several months ago, a 5½ hour fire gutted a warehouse in downtown Philadelphia. A Fire Chief was heard to remark: "Fifth floor of the building was filled with very volatile things—plastics and stuff." This statement points up the dire need for education—not only for responsible public officials but for the general public as well. Plastics aren't volatile. Some of them are difficult to ignite and are self-extinguishing, such as PVC, phenolics, and melamines. Others, such as polystyrene and polyethylene, depending upon formulation, will burn. But the point is that even the most flammable of plastics are not as flammable as other common materials stored in warehouses all over the country, for example, paper, lumber, and textiles. Yet none of these materials seem to have the reputation for "flammability" that plastics have.

The argument is often made that these other materials such as paper can be flameproofed by adding various agents, such as ammonium sulfamate or borates or silicates. The fact is that these materials can be made flame-resistant to pass certain standards as outlined by various industry groups. However, in a book published by the Institute of Paper Chemistry the statement is made that it is generally recognized that it is impossible to render cellulosic materials incombustible. Similarly, plastics can be made self-extinguishing, the term used in this industry—that is the material once ignited will not continue to burn. Cellulose acetate, for example has a burning rate of from 0.5 to 2.0 inches per minute but can be formulated so that it is self-extinguishing. Polyethylene has a burning rate of from 1.0 to 2.0 inches per minute but it too can be made self-extinguishing. This brings to mind an interesting phenomenon: It is virtually impossible to obtain burning rate data on cellulose-based materials.

The age of plastics in buildings is upon us. If we are to successfully engineer the use of plastics in structural applications, we must at the same time engineer a change in the outlook of a large segment of the public, including fire department personnel. This is a job calling for serious and coordinated action by the major organizations in the plastics field. The Manufacturing Chemists' Association, it seems has signalled a good start with the recent publication of a safety guide entitled "Plastic Foams—Storage, Handling, and Fabrication" in which MCA indicates that fire-safe storage of plastic foams calls for no "special precautions beyond those typically afforded piles of lumber and other such combustibles."

Nature provides safe...



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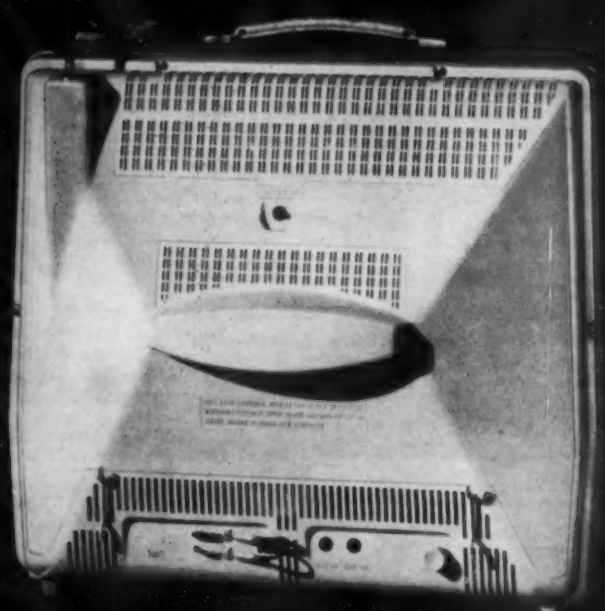

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Letters

Interest in Education

Dear Sir:

In your article "SPE Education Committee Surveys Polymer Courses" (Dec. 1960 SPE Journal), I find that you have omitted mention of the polymer courses available at the College of Forestry, Syracuse University. It is my understanding that Dr. Jahn, Associate Dean of Physical Sciences, of the College of Forestry has written to you listing the polymer courses available here. I do hope that you will make this correction in future articles and please do not forget to list the College of Forestry in the SPE follow-up brochure "Engineering Education in Plastics."

John A. Meyer
Chairman, Education Committee
Central New York Section, SPE

Dear Sir:

I have contacted Mr. Hiram McCann, Editor-in-Chief of Modern Plastics, concerning courses in plastics and he has referred me to you.

I am interested in finding out if the two year course in plastics (offered at the Los Angeles Trade Technical College) or one similar to it, can be taken by correspondence. I would be interested in any good quality courses, particularly on molding techniques for the various plastics.

My present job involves quite a bit of work with plastic materials and I feel that a course such as the one described would be very beneficial to me.

D. C. Stapleton
Materials Engineering
IBM, Electric Typewriter Division

Editor's Note

Mr. Stapleton was referred to the Dept. of Correspondence Instruction, Univ. of Calif. Ext., Berkeley 4, Calif., Engineering X497—Survey of Plastics.

High Shear Viscometer

Dear Sir:

In your publication, Volume 16, No. 12, for December 1960, you ran an article entitled, "Melt Index Equivalent —New Flow Parameter." I found this article very interesting and believe it is potentially helpful.

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L. B. Cundiff
Technical Superintendent
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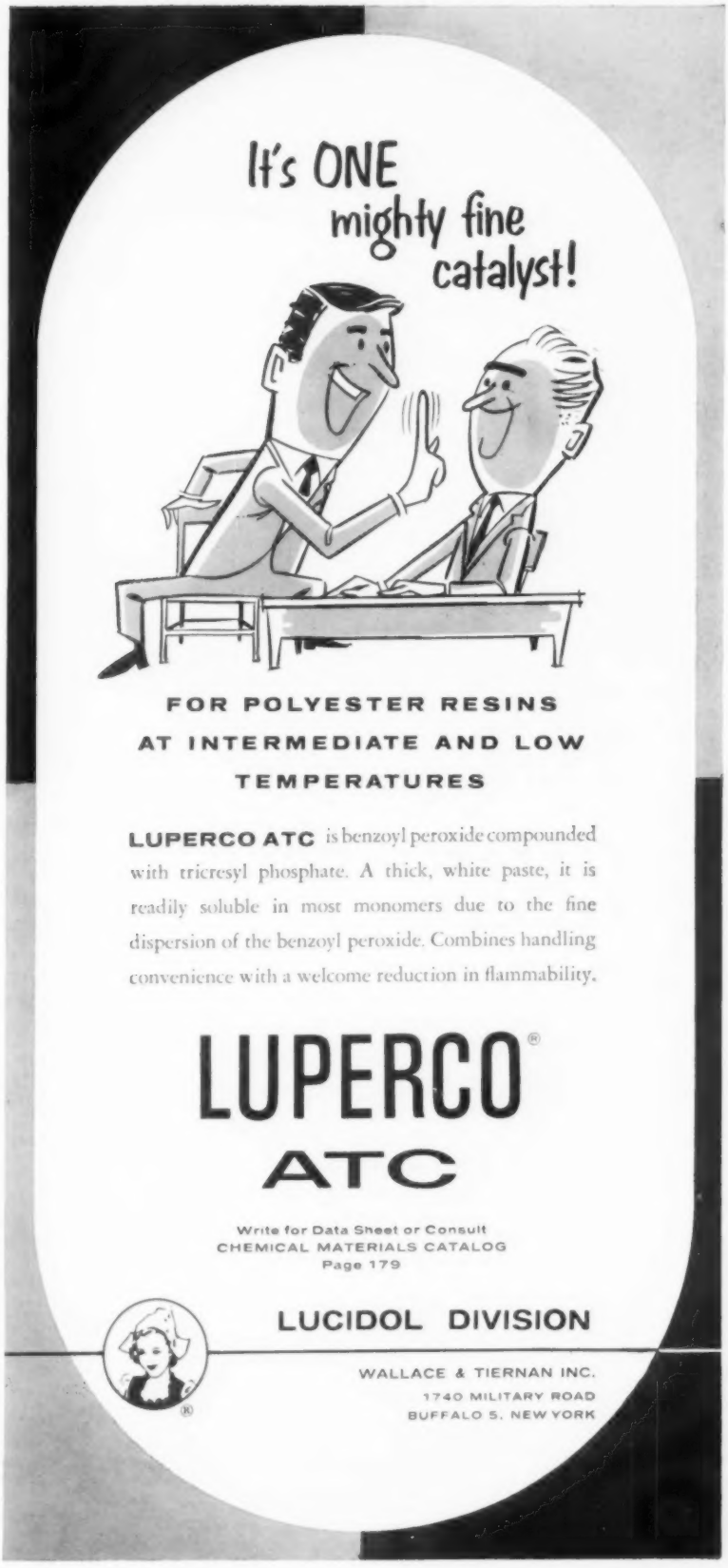
Editor's Note

For additional information, it is suggested that you write to Dr. A. Rudin, Central Research Laboratory, Canadian Industries, Ltd., McMasterville, Quebec, Canada.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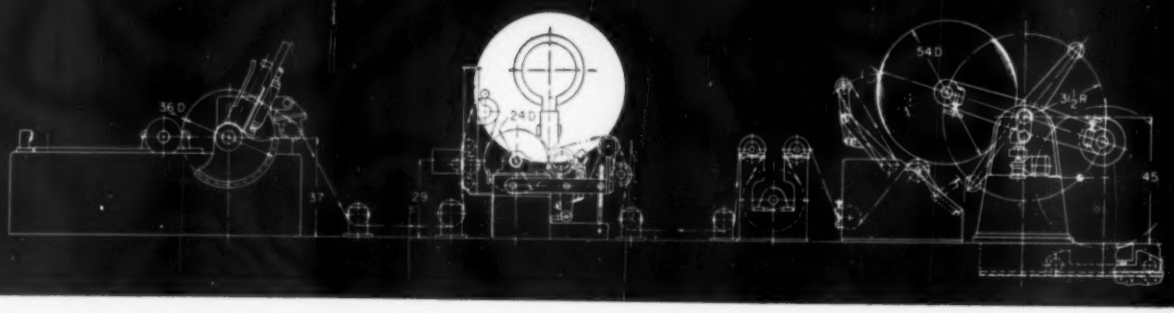

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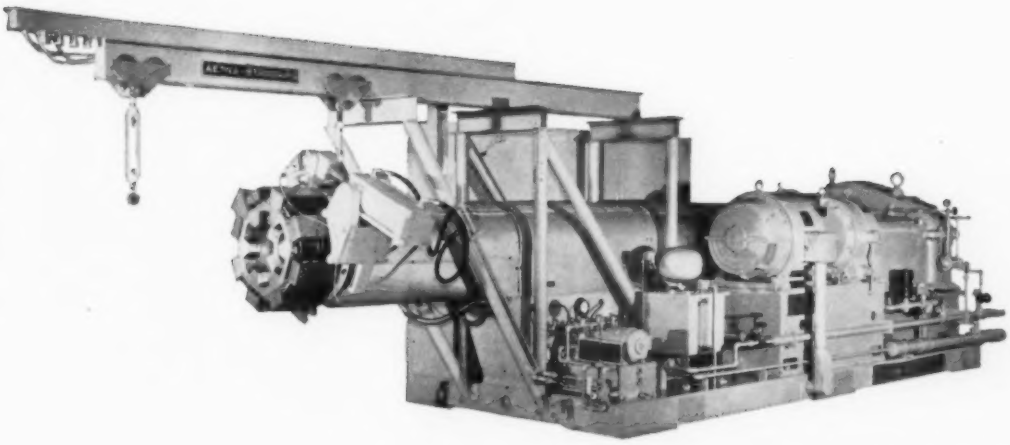

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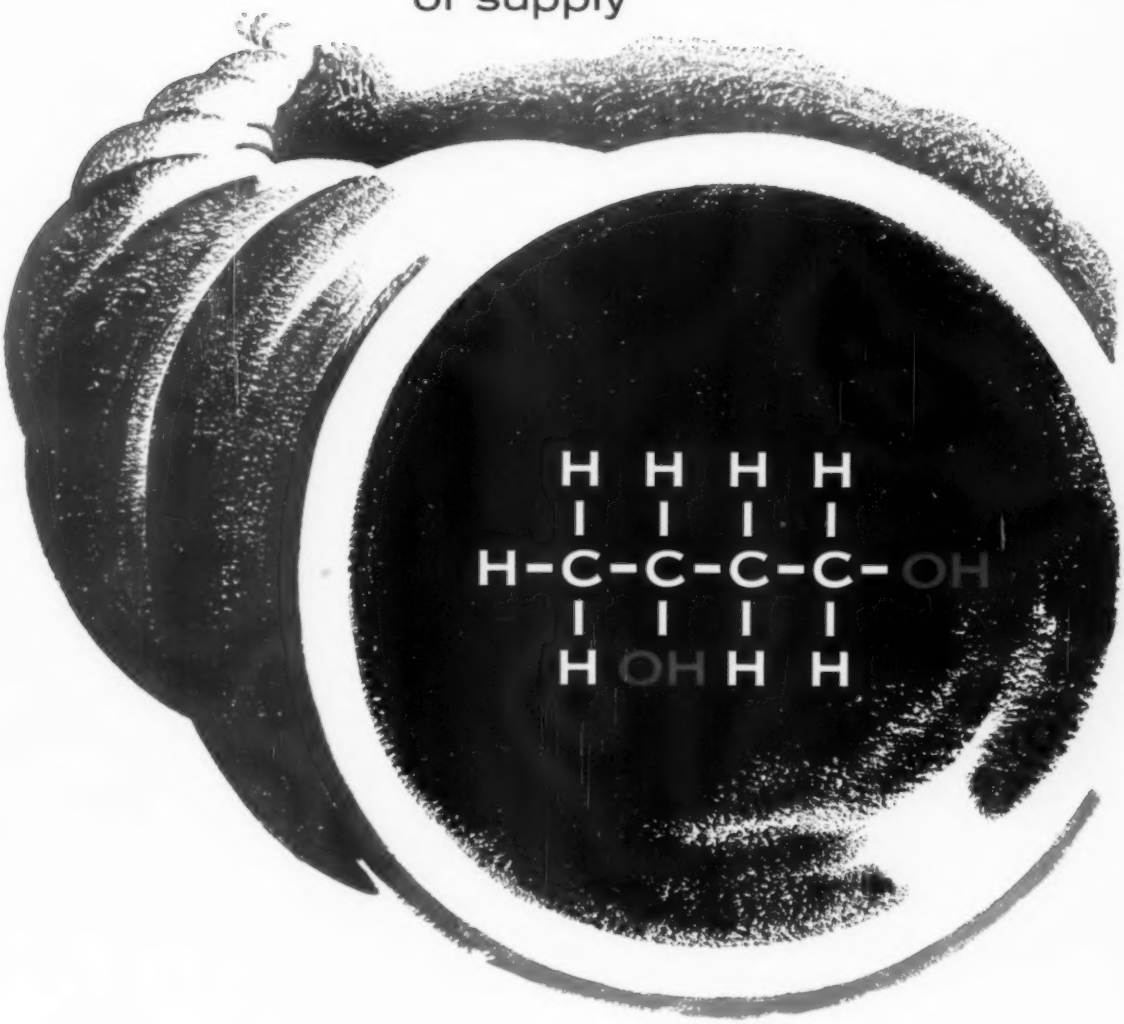

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SPE JOURNAL NEWSLETTER

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Diagrams Predict Properties

Thermodynamic diagrams for polyethylene resins may be used to predict crystallinity, specific heat, and other important characteristics and to follow charges in these characteristics as the resins are heated or cooled. Developed by J. M. Lupton of Du Pont, the diagrams can also be used to estimate properties of resins that have not yet been synthesized. Accuracy is reported to be sufficient for most engineering purposes.

Reinforced Poly(vinyl chloride)

Rigid Poly(vinyl chloride) sheet can now be given structural strength to compare with that of reinforced plastics. The new method of fabrication consists essentially of applying a special polyester resin and glass fiber reinforcement directly onto one side of PVC sheeting by means of wet layup or spray techniques, leaving the other side of the PVC for exposure to chemicals or other materials to be processes. Reported key to the success of this method: A specially-formulated polyester resin made in Britain.

Better Injection Molding

Injection molding machines may be upgraded by installing a rotating spreader or topedo in the injection cylinder. Operation of machines equipped with the rotating spreader disclosed major improvements in molding quality, production rates, and color mixing. Complete changeover of a 6-ounce machine costs in the neighborhood of $2000. When a new cylinder and plunger must be purchased, cost will be about $4000, depending on drive selected and modifications to hydraulic system.

Plastic Powders

Foamed plastic powders can be made by collecting foamed plastic particles (page 249). The particles can be readily colored or metallized, can be prepared in open or closed cell form, and in a wide range of particle sizes. Possible uses: Fillers for paints, plastics; ion exchange resins; fluidized beds; packing for aircraft wings, tires, etc.

SPI Conference in Chicago

Over 1250 persons attended The Society of the Plastics Industry's, Inc., 16th Conference of the Reinforced Plastics Division, in Chicago. In a design competition sponsored by SPI, a U.S. Navy 26-foot whaleboat, with molded-in flotation compartments and a plastic-shrouded engine, won first prize. The boat was molded by Lunn Laminates, Inc. Other winners were a tow target, water skis, and translucent building panel.

Plastics — A New Dimension in Buildings

TECHNICAL MEETING TO HIGHLIGHT PLASTICS IN BUILDINGS

April 20, 1961
Springfield Museum of Fine Arts
Springfield, Massachusetts

"Plastics—A New Dimension in Buildings" will be the subject of an SPE Regional Technical Conference sponsored by the Western New England Section in Springfield, Massachusetts on April 20, 1961. To be held at the Springfield Museum of Fine Arts, the Conference will coincide with the first showing of an educational traveling exhibit demonstrating the application of plastics in buildings—in construction and interiors and for decorative purposes.

The technical program, developed with the cooperation of SPE's Plastics in Buildings Professional Activity Group, features leading experts in the use of plastics materials in modern architecture and construction. Among the subjects to be discussed are plastics in building exteriors, importance of structural and dimensional stability of plastics materials, resistance to weathering, thermal insulation and plastics in lighting applications. Keynoting the conference will be Harold Horowitz, Assistant Director for Technical Programs of the Building Research Institute. Luncheon speakers will be Frank W. Reynolds, SPE President, and Philip George of George Nelson Company who will discuss "Interior Designing of Plastics."

The Conference preprint book will include copies of all papers presented at the technical sessions as well as additional papers on other aspects of the subject. In this manner, the preprint will be a comprehensive technical summation of current applications and technology. The complete technical program as announced by Program Chairman Armand G. Winfield of DeBell & Richardson is listed at right.

Advance registration fees are $11.00 for SPE members and $12.00 for non-members. Registration at the conference will be $1.00 additional in each case. A special student registration fee of $6.00 has been established specifically for this meeting. Advance registrations should be addressed to:

Blakely R. McNeill,
RETEC Registration Chairman
c/o Fuller Brush Company
Hartford 15, Connecticut

Further information is available from the General Chairman of the Conference, Robert W. Sherman of Union Carbide Plastics Company. Other major committee Chairmen include: House—Robert E. Pollard, Monsanto Chemical Co; Publicity—Wesley S. Larson, DeBell & Richardson; Printing—Russell E. Jacobson, Plax Corporation; and Treasurer—Lawrence D. Burkinshaw, General Electric Co.

Technical Sessions

Architectural Moderator: Burton Holmes
Technical Editor, Progressive Architecture

Plastics Moderator: Melvyn A. Kohudic
Editor, SPE Journal and SPE Transactions

Speakers: **Keynote Address**
Harold Horowitz
Building Research Institute

"Use of Plastics in Building Exteriors"
James Keller and John P. Wittemore
Kalwall Corporation

"Thermal Insulation
H. W. Tenney
Dow Chemical Company

"Structural Aspects of Plastics"
James Lunn
Lunn Laminates

"Resistance of Plastics to Weathering"
J. D. Matlack and G. R. Rugger
Picatinny Arsenal

"Use of Plastics in Lighting Applications"
Noel Florence
Light-O-Lier Corporation

"Importance of Structural and Dimensional Stability in Plastics"
Dr. Frederick J. McGarry
Massachusetts Institute of Technology

Summation Address
Dr. Serge Chermayeff
Harvard University

Conference Luncheon

Moderator: Frederick B. Robinson
Springfield Museum of Fine Arts

Speakers: **"The Challenge of the Future"**
Frank W. Reynolds
SPE President
IBM Corporation

"Interior Designing with Plastics"
Philip George
George Nelson Company

U.S.I. POLYETHYLENE NEWS

A series of advertisements for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

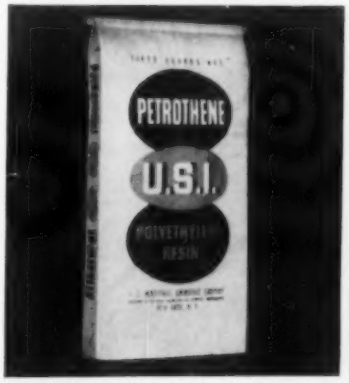
Packaging Notes

On-the-spot polyethylene skin packaging is revolutionizing the moving industry. With a new portable machine which can be rolled right into a home and run on any 110-120 volt circuit,

barrel packing can now be accomplished in 25% less time at a 33% savings in material costs. Device applies a tight, 6-mil polyethylene film cover over small or fragile articles, anchoring them firmly to a polyethylene-covered corrugated board. Full cycle is said to take less than 30 seconds. Standard moving barrels are used.

Because of its easy portability, this machine is also being utilized by manufacturers for in-plant packaging of electrical components, spare parts, etc.

New Bag For U.S.I. PETROTHENE® Resins



A newly-designed 50-lb. bag now packages U. S. I. premium PETROTHENE resins. It has an outer ply of semi-bleached Kraft, imprinted with a new 3-oval U.S.I. insignia. Look for this bright white, red and black bag, instead of the familiar red on brown one, next time you order.

Blow Molding Upturn Ushers In New Products

May Yet Rank With Injection Molding As Polyethylene Market

Blow molding, a 50-million-pound polyethylene market in 1960, is expected to show dynamic growth in 1961. Predicts Vincent D. McCarthy, Director of Plastic Sales for the U.S. Industrial Chemicals Co.: "This year blow molding will climb faster than ever . . . and may eventually compare with injection molding as a market for polyethylene." Injection molding now consumes 250 million pounds of conventional polyethylene yearly.

"The tremendous growth of blow molding high density polyethylene has also created a substantial demand for blow molding conventional polyethylene," he explains. "The use of conventional resins, either by themselves or in blends with high density resins, will continue to increase."

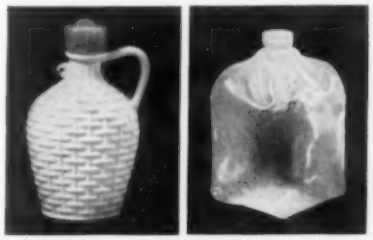
Technical advances are also contributing to blow molding's upward trend —spurring new products, creating new applications.

A Long Island, N. Y., plastics company, for example, is now making a walking doll 40 inches tall. New techniques, the recent acquisition of extremely large blow-molding equipment, and the consistent uniformity of the U.S.I. resin used are credited with making production possible.

And, from Europe comes report of the popularity of a polyethylene wine flask. Blow-molded in Portugal from a PETROTHENE resin, it's said to be ideal for short-time storage. A simple treatment overcomes any influence of polyethylene on flavor: Filling the container with pure water, leaving it for 24 hours, then emptying apparently does it.

In this country, news is being made by a 5-gallon *collapsible* jug—extrusion blow-molded from PETROTHENE by a Cleveland concern. This corrosion-resistant container can transport and store virtually any liquid, costs only about 90¢ with cardboard carton.

DOLL BODIES blow-molded of polyethylene to proportions of 2-, 3-, and 4-year olds. The biggest doll is 40 inches tall.



WINE FLASK and COLLAPSIBLE 5-GALLON JUG are typical of new products being blow-molded of U.S.I.'s PETROTHENE polyethylene resins.

Hot-Transfer Process to Decorate 300,000,000 Bottles

The tide of blow-molded bottles decorated by the relatively new hot-transfer method is rising steadily. According to the company developing the process, it will be applied to more than 300 million plastic bottles during 1961.

Success of the technique is attributed to both its efficiency, and the recent breakthrough of low-cost, semi-rigid polyethylene bottles.

Reportedly, equipment is now available for applying multicolor designs to bottles of any shape "at speeds up to 100 units a minute at a fraction of the cost by other methods."

Automatic machine applies wrap-around labels to cone-shaped bottles. Design is reverse-printed on heat-release coating. Post-heating ovens impart gloss to the transferred printing.

Pipe, Fittings of Polyethylene OK'd by New York City

For the first time, the N.Y.C. Board of Standards and Appeals has approved polyethylene pipe and fittings for acid and chemical waste systems. The approved drainlines, made by a Rochester, N. Y., company, are now also acceptable to Buffalo, Cincinnati, Detroit, Los Angeles, the State Plumbing Code of Michigan and the Plumbers' Examining Board of Richmond, Va.

U.S.I.

Series VI, No. 2

POLYETHYLENE PROCESSING TIPS

HOW TO PREVENT RESIN CONTAMINATION IN YOUR PLANT

Contamination in polyethylene resins can mean increased down-time and lower product quality. Both are costly results which can be prevented by a few simple precautions in handling and processing resin.

The producer, of course, has the responsibility to make sure that resin arrives at your plant in virtually contamination-free condition. U.S.I., for example, carries out strict quality control sampling of every PETROTHENE® polyethylene lot produced at its Tuscola, Ill., and Houston, Tex., plants. Engineers also maintain a constant check on production and handling facilities to detect possible sources of contamination before they can cause trouble.

Once the resin arrives at the customer's plant, it is his responsibility to prevent contamination during handling and processing steps. This is relatively simple if he follows the basic procedures outlined below.

Check the Container

There need be no question about the purity of PETROTHENE resin arriving at the processor's plant if the container is *sealed*. While all due care is taken in packaging and loading resins, some container breakage may occur.

Resin in containers arriving either broken or opened should not be used unless it is definitely established that no contamination has occurred. Instances of opened or broken containers should be reported immediately to the nearest U.S.I. sales office. This can help U.S.I. in determining where the breakage occurred and preventing its happening again.

In-Plant Conveying

Polyethylene resins are transported from their point of arrival in a processor's plant to the processing machine in a variety of ways. Which method is used depends on the type of container the resin is in and the size and type of processing operation involved.

In large operations, where Dry-Flo* carlots of resin are used, conveying systems are usually installed to move the resin either directly from the car to the processing machine, or from the car to storage silos, and eventually, to the processing machine. Where this is the case, the conveying system should be inspected regularly for loose fitting sections or other possible contamination entry points.

Hopper loaders of one type or another must be used with Sealdbin† shipments of polyethylene resin. These loaders should be designed to eliminate resin hang-up and checked regularly for possible points where contaminants can enter.

An important rule to remember is that any resin loading system should be closed. Resin containers or equipment hoppers which remain uncovered for long periods of time are a major cause of resin contamination.

Opening Bags

Most U.S.I. PETROTHENE polyethylene resin is shipped in 50-lb. multiwall paper bags. The inner ply has a coating of polyethylene to protect the resin from contamination by paper fibers, moisture and other foreign matter. Unfortunately, unless the bag is opened with care, bits of foreign matter may get mixed in with the resin.

First step before opening a bag is to brush the top section of the bag clean of any loose dirt and dust. Usually there is some, as this is unavoidable in shipping and storage.

Do not use a knife to open a bag. This will lead to contamination by paper fibers. The proper way is to open the bag by pulling apart the strings used to close its top after filling. The simple procedure for opening the bag is described in the data sheet, "How to Open a Polyethylene Resin Bag", which can be obtained from U.S.I. on request.

Opening Cardboard Containers

Cardboard containers of PETROTHENE resin are sealed with metal bands. In opening these containers, too, it is important to first wipe the top to remove dirt and dust which may have accumulated. As in the case with 50-lb. bags, cardboard boxes should never be opened with a knife. The proper method is to cut the metal bands and remove the container lid. The polyethylene liner found inside all U.S.I. cardboard containers should then be unfolded and placed over the top edge of the box before discharge of the resin. This liner helps further to protect the resin from contamination between charges to the processing machine hopper. The liner should be used to recover the unused resin before replacing the container lid.

Good Housekeeping

Even when all the above precautions are taken, some resin contamination may result from poor shop housekeeping. Processing areas should be kept clean so that dust and dirt, which can contaminate the resin during the brief intervals when it is uncovered, are kept to a minimum. A dirty processing area will always cause some degree of resin contamination, regardless of other steps taken to prevent it.

The last place where resin contamination can occur is in the processing machinery itself. Since this "Processing Tip" is primarily concerned with eliminating foreign material in the resin cubes and pellets, listing good processing practices in detail is beyond its scope. It is important to remember, however, that regular maintenance and cleaning of processing machinery not only will prevent resin contamination but also will insure optimum machinery and resin performance.

*Registered trademark of General American Transportation Corporation.

†Registered trademark of United States Rubber Co.

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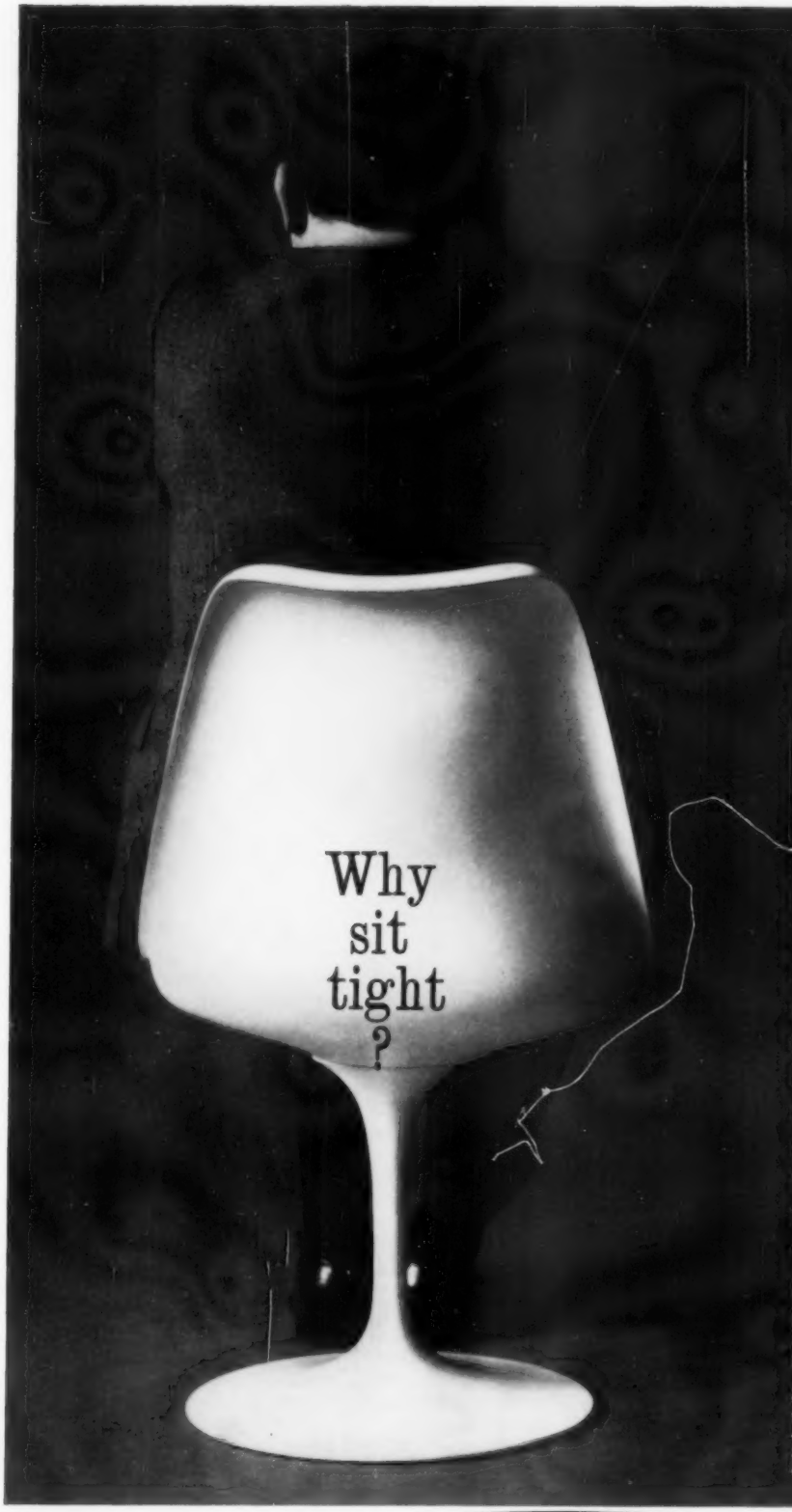

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If you find yourself in the "cut cost — keep quality" squeeze (and who isn't these days), you can expect real help from Plastolein 9720. This is because 9720 contributes the quality characteristics of a polymeric, yet is the *lowest* cost polymeric available today.

9720 offers excellent permanence in terms of low volatility, low migration, and resistance to "wipe off," heat and ultraviolet light—which make it an ideal primary plasticizer for many formulations. And its ability to match the low temperature properties of many monomerics vastly widens the range of its uses.

Also—9720—which processes like most monomerics —is fluid enough to be handled economically in bulk.

All this explains why time-tested 9720 is the largest selling polymeric today. Why not let this talented low-cost performer take you out of the "cut cost—keep quality" squeeze. For complete details write Dept. J-3 for booklet—"Plastolein Plasticizers."

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Special Feature

A safety program for handling liquid thermosetting resins

Although the information primarily applies to end use applications rather than manufacturing, the program is valid in every phase of resin handling

Charles A. Harper
Westinghouse Electric Corp., Air Arm Division
Baltimore, Maryland

Safety in the handling of liquid, thermosetting resins has, perhaps, been much more publicized than practiced. Most likely reasons for this condition are (1) the fact that one cannot accurately isolate, in advance, those persons who will be affected by the personal hazards, (2) the biological complexities of some of these problems which often do not allow simple, rapid and positive relief for those persons affected by resins, and (3) the normal psychological problem of getting people to properly observe preventive safety practices without strict enforcement.

With these conditions existing, preventive safety measures are often ignored, with the remedial action consisting of removing the affected person from the job once he has been affected. A more aggressive approach is a strict, clean housekeeping practice. Although there can be no disagreement to the value of good housekeeping, there are practical steps beyond solely this approach which can be very helpful in minimizing safety problems with resins. The hazard most commonly affected by the above points is the dermatoses problem. It should be pointed out here, however, that every safety practice mentioned in this article must be in addition to good housekeeping, good personal practices and sensible handling and storage procedures.

THE DERMATOSES PROBLEM

Dermatoses is undoubtedly the most studied safety problem associated with resins. Prolonged, direct skin contact with any of the thermosetting resins can lead to dermatoses. Nevertheless, epoxy resins are generally considered to present a greater dermatoses problem than any other type of liquid, thermosetting resin. Nearly every supplier of epoxy resins has developed standard data sheets on the handling of epoxy resins. In addition, many groups and individuals have studied the problem of dermatoses with epoxy resins in order to isolate the causes of and cures for the problem. The results of and conclusions from some of these studies will be presented at this point.

Studies on the Dermatoses Problem—Major investigations on this problem have been conducted and reported by Shell Chemical Corporation, Ciba Products Corp., Union Carbide Plastics Company, Dr. E. Grandjean, Director of the Institute of Hygiene and Industrial Physiology of the

The two main sources of information for this article were (1) a book entitled "ELECTRONIC PACKAGING WITH RESINS—A Practical Guide for Materials and Manufacturing Techniques", written by C. A. Harper, Westinghouse Electric Corporation, and to be published by McGraw-Hill Book Co., Inc., about April 1961, and (2) communications of the author with numerous leaders in the industry, as are acknowledged in the remainder of this article.

Swiss Federal Institute of Technology, and Dr. Louis C. Barail, President of Barail Associates, Consulting Toxicologists of New York.

The investigation of Dr. Grandjean consisted of a study of eleven electrical plants in which amine-cured epoxy resins were used. He studied the sources of dermatoses with epoxy resins and the nature of the dermatoses condition. He concluded that (1) both the uncured resin and the hardener are capable of causing epidermal irritations by skin contact; (2) once a person has been sensitized by previous contact, vapors of the resin or hardener can cause a recurrence of the epidermal irritation, (3) the frequency of epidermal contact with resins and hardeners is of decisive importance in determining the frequency of occurrence of dermatoses and (4) epidermal contact with resins and hardeners is often made by transfer from cleaning rags, solvents, and other soiled objects.

Dr. Grandjean observed that the epidermal irritation usually proceeded as follows:

After an interval free of symptoms, which may last a week or many months, red patches (erythema) about the size of a coin first appear on the underside of the lower arm or in the region of the lower eyelid. They also often appear on the back of the hands, on the fingers, and on various parts of the face and neck. This first stage may heal by scaling of the patches after a period of several days to three weeks and the itching then disappears.

If the first stage of the dermatosis does not heal, the second stage consists of the formation of a true cutaneous eruption with red pimples and the formation of blisters. The intense itching causes the patients to scratch open blisters and skin. The inflamed parts of the skin are swollen, deep red, and wet with exuding tissue fluid. Continuation of work is no longer possible at this stage. If the eczema heals later, it first scales and then disappears after several weeks.

Dr. Louis C. Barail, President of Barail Associates, Consulting Biochemist-Toxicologist of New York City, has tested over 200 resin compounds for toxicity. His findings agree with those Dr. Grandjean obtained in Switzerland. However, he points out that quite a few resins which are not primary skin irritants are potent cutaneous sensitizers.

The Shell, Ciba and Union Carbide investigations go further into physiological studies of the effects of various resins and hardeners by tests on rats and rabbits, and by patch tests on humans (1, 2, and 3). From these tests, the generalization can be drawn that resins are less prone to cause dermatoses than are amine curing agents and that solid epoxy resins are less likely to cause skin disorders than the more reactive liquid resins.

Table 1. Summary of Skin Effects Produced by a Single One-Hour Application of Curing Agents to the Skin of Rabbits[1]

Curing Agent Applied to the Skin	Concentration	Effect
Diethylenetriamine (DTA)[a]	Undiluted	Eschar, erythema and edema
Epoxy Curing Agent U	50% in Acetone	No effect
Epoxy Curing Agent BF_3-400[b]	50% in Acetone	No effect
Epoxy Curing Agent T[b]	Undiluted	No effect
Epoxy Curing Agent D[b]	Undiluted	No effect

[a] Undiluted DTA produced moderate irritation in one minute and burns and resultant scarring in three minutes.
[b] These compounds produced no irritation following seven hours of contact with the skin.
[1] Courtesy of the Shell Chemical Corp.

Table 2. Summary of Skin Effects Produced by Repeated Seven-Hour Per Day Applications of Curing Agents to The Skin of Rabbits[1]

Curing Agent Applied to the Skin	Concentration	Effect
Diethylenetriamine (DTA)	50% in Acetone	Eschar produced in 1 hour
Epoxy Curing Agent U	50% in Acetone	Severe eschar after 3 applications.
Epoxy Curing Agent T	Undiluted	Erythema and slight eschar after 3 applications.
Epoxy Curing Agent BF_3-400	50% in Acetone	Erythema and eschar after 3 applications.

[1] Courtesy of the Shell Chemical Corp.

Resins—Mild eye-irritating properties of uncured epoxy resins were determined by observation of the degree of corneal irritation developing in 1, 24 and 48 hours following the introduction of the resins into the eyes of rabbits. The cornea was observed unstained and after staining with 2% sodium fluorescein.

Because of the improbability of contamination of the eyes coincident with the use of these resins in industry (because of their high viscosity or the solid state in which they exist) eye irritation should generally not be a problem if sensible handling practices are observed.

Irritating Properties of Epoxy Resin Curing Agents

As shown in *Tables 1 and 2*, all curing agents are primary irritants when applied to the skin of animals in sufficient concentration and/or with sufficient frequency. Further, these tables show that there is wide variation in the inherent irritating properties of the individual curing agents. All aliphatic amines—diethylenetriamine (DTA), diethylaminopropylamine (Epoxy Curing Agent A), and triethylenetetramine—are caustic materials which can cause severe injury when in contact with the skin for a relatively short period of time. The second group of amines, including Epoxy Curing Agents T-1, U, Z, and metaphenylenediamine (Epon Curing Agent CL), will cause staining when in direct contact with the skin. These materials may also sublime when heated and cause staining of the clothing, equipment and the working area unless proper ventilation is utilized.

Sensitizing Potentialities of Epoxy Curing Agents

Sensitization, frequently displayed as a recurrent-type dermatitis, has been observed to be induced in some individuals following a protracted period of severe and uncontrolled exposure to some of the curing agents. Under such conditions, individuals have been sensitized to the extent that recurrent dermatitis has been produced following each subsequent overexposure to the curing agents, even in vapor form. Thus, the more volatile amine curing agents—diethylenetriamine, triethylenetetramine and diethylaminopropylamine (Epoxy Curing Agent A)—have been observed to produce recurrent dermatitis in sensitized individuals more readily than the modified amine cur-

ing agents of greater viscosity and lower volatility such as Epoxy Curing Agents U and Z. Epoxy Curing Agent BF_3 - 400, metaphenylenediamine (Epoxy Curing Agent CL) and dicyandiamide are solids at room temperature and have been found to be the least reactive with respect to sensitization. Epoxy Curing Agent T-1 appears to be one of the least sensitizing of the commonly used curing agents.

Union Carbide has reported on human patch tests with two commonly used hardeners, diethylene triamine and N, N- bishydroxyethyl diethylene triamine. Diethylene triamine is a caustic amine which in concentrated form can cause skin and eye burns. It is capable of penetrating the skin in harmful amounts and is a strong sensitizer, even when tested on humans as a 10% solution. In contrast, N, N-bis-hydroxyethyl diethylene triamine is not an active skin irritant. Human patch tests with a 10% solution do not show skin irritation or sensitization.

All uncombined amines are capable of causing tissue damage when in contact with the skin in sufficient concentration for a sufficient period of time. They are capable of causing eye burns, and their vapors are irritating.

Dermatoses from Reactive Diluents and Solvents

Solvents, e.g., methyl isobutyl ketone, xylene, etc., which are used in some epoxy resin formulations, are primary skin irritants because of their ability to remove natural oils from the skin. Although sensitization is not associated directly with solvents, they render the skin more vulnerable to attack by the more potent dermatitis-producing components of epoxy resin formulations. In this manner, they may enhance the sensitizing potentialities of the other materials. Also, unclean solvents used for epoxy clean-up can transfer sensitizing agents from epoxy systems.

Generally speaking, reactive diluents (allyl and phenyl glycidyl ethers, etc.) have dermatitic tendencies equal to or exceeding those of liquid epoxy resins.

Summary of the Dermatoses Problem

Although dermatoses can be caused by repeated exposure to any resin under some conditions, epoxy resin systems are the most frequent source of this problem. Epidermal sensitization and irritation in epoxy systems can be caused by uncured epoxy resins, hardeners, reactive diluents, and contaminated solvents and objects. The worst of this group are the amine hardeners, which vary in activity, but are generally more potent for the higher volatility, faster curing and most reactive amines, such as the aliphatic amines (diethylenetriamine, triethylenetetramine, and diethylaminopropylamine are typical). There is no reliable way of determining in advance which persons will be affected. Dermatoses can occur in a few days, or it may take weeks or months to occur, depending on the individual, the materials used, and cleanliness of the operation, the frequency of contact, and other individual operating conditions. There is no generalized simple cure for a contracted dermatoses condition. Hence, protective measures must be used for minimizing the dermatoses problem.

For specific safety measures, the reader is referred to the detachable booklet which has been specially prepared for the SPE Journal.

TOXICITY PROBLEMS

There are two resin systems whose toxicity problems can become acute. These are: Diisocyanate foams and resins, and the epoxy resin-solid acid anhydride curing agent systems.

Diisocyanate Resin Systems

The diisocyanate reactant of the diisocyanate resin systems, toluene diisocyanate (TDI) is volatile and toxic. These resin systems are also known as urethanes, polyurethanes, polyester foams, polyether foams, or as isocyanates. These are most commonly used to produce rigid and flexible foams, but are also used to make high density elastomers. The presence of TDI causes coughing, eye watering, and choking. These effects, plus the TDI odor, give an immediate indication of its presence. Continuous or prolonged exposure to TDI vapors will produce a raw throat effect, and possibly serious respiratory disorders.

Considerable work has been done by Du Pont and by Mine Safety Appliances Company on determining the safe concentrations of TDI vapors in the air. It has been determined that good industrial hygiene practice requires restriction of TDI vapors to concentrations below 0.10 ppm in

SOME SUPPLIERS OF RESIN HANDLING EQUIPMENT

Auto-Air Industries, 621 North Cedar, Lansing 6, Michigan.
Automatic Process Control, 1170 Morris Avenue, Union, New Jersey.
Bell and Gossett Company, Morton Grove, Illinois.
Delsen Corporation, 719 West Broadway, Glendale, California.
H. V. Hardman Company, 571 Courtlandt Street, Belleville 9, New Jersey.
Hull-Standard Corp., Davisville Road, Hatboro, Pennsylvania.
Isocyanate Products, Inc., Wilmington 99, Delaware.
Jennings Engineering Co., 3444 Ludlow Street, Philadelphia 4, Pennsylvania.
Leon Machine & Engineering Co., 61 Whittaker Street, Riverside, New Jersey.
G. Diehl Mateer, 955 Lincoln Highway, Stratford, Wayne, Penna.
Mechanical Handling Systems, Inc., 4600 Nancy Avenue, Detroit, Michigan.
Meter-Mix Corporation, Div., Federal Tool Co., 626 Dorchester Avenue, Boston 27, Massachusetts.
Murphy and Miller, Inc., 600 West Taylor Street, Chicago 7, Illinois.
Mitchell Specialty Div., Industrial Enterprises, Inc., Edmund and Shelmire Streets, Philadelphia 36, Pennsylvania.
National Instrument Laboratories, 878 Evarts Street, N. E. Washington, D. C.
Pyles Industries, Inc., 20855 Telegraph Road, Detroit 41, Michigan.
Red Point Corp., 1907 Riverside Drive, Glendale, California.
Semco Research, Inc., 212 West Florence Avenue, Inglewood 1, California.
Martin Sweets Co., 114 South First Street, Louisville 2, Kentucky.
Gabriel Williams, 77 Mill Road, Freeport, Long Island, New York.

air. As a means of controlling these vapors, DuPont and Mine Safety Appliances Company have developed a colorimetric technique and an apparatus for measuring TDI vapor concentrations. In brief, the monitoring technique depends upon rapid hydrolysis of the diisocyanate to the corresponding diamine derivative; diazotization of the diamine in the presence of nitrous acid; destruction of the excess nitrous acid with sulfamic acid; and finally the coupling of the stable diazo compound at room temperature with N-1 naphthylethylene diamine to produce a reddish blue color that is measured colorimetrically.

The diazometric method has been incorporated into a portable analytical kit that allows the entire analysis consisting of air sampling, color formation, and color comparison with stable plastic standards, to be performed by operating personnel immediately in the area where TDI is employed. Its operation is shown in the accompanying photograph.

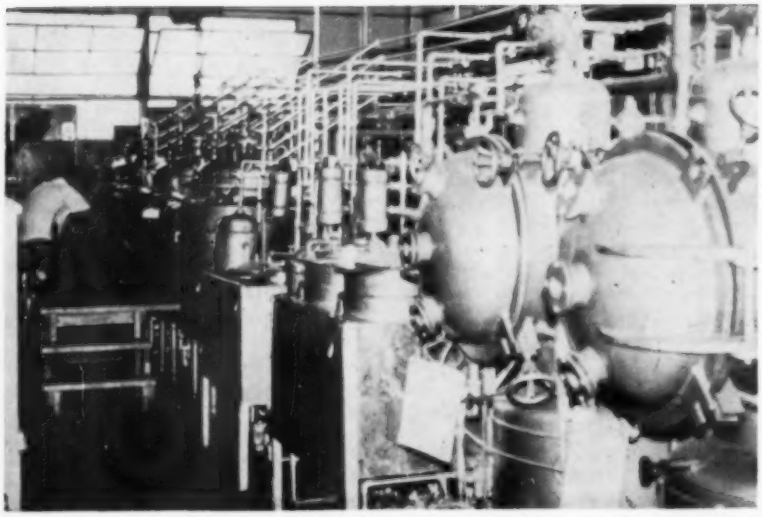

Figure 1. Impregnation processing in closed equipment to minimize handling hazards (photo courtesy Electron Products Div., Marshall Industries)

Epoxy-Solid Acid Anhydride Systems

Acids and acid anhydrides used with epoxy resins normally have lachrymatic tendencies. They cause the eyes to water, and can also cause respiratory disorders such as coughing or choking. These solid materials, such as phthalic anhydride, maleic anhydride, chlorendic anhydride, etc., require heating of the resin and acid in order to obtain solution of the acid in the resin. This heating further aggravates the toxicity problems.

For comparative information to the reader on other epoxy systems, Shell Chemical Company has reported extensive tests on toxicological studies with cured and uncured epoxy resin. The net conclusion from these studies is that cured epoxy resins are toxicologically inert at all levels of dosage. Slight toxicity is observed by ingestion of high doses of the lower molecular weight uncured epoxy resins. Hence, toxicity problems with the base uncured epoxy resins, and with cured epoxy resins, are more academic than real due to the low volatility of these materials. Toxicity with curing agents is more acute, however. In tests on rats, Ciba has arrived at approximately the same conclusion regarding the toxicity of epoxy resins.

Safety Measures for Minimizing Toxicity Problems

The safety practices of good housekeeping and personal hygiene already outlined in the detachable booklet are still very important, although not as critical as in the dermatoses problem. However, adequate ventilation is extremely important for toxicity prevention. In applications involving the use of diisocyanate resins, the monitoring equipment discussed can be used to accurately control vapor concentrations at safe levels.

As with the dermatitis problem, proper material choices can also be very helpul in minimizing toxicity problems. For instance, diisocyanates are available as "one shot" or "prepolymer" formulations. The one shot formulations employ free TDI, and hence, present the most serious toxicity problem. The prepolymer formulations are supplied with the TDI partially prepolymerized; thus, having a much lower concentration of free TDI, the toxicity problem is considerably reduced. Where toxicity is a problem, the prepolymers can often be used to advantage. There are, of course, debated points on the technical merits of each. These debates can be taken into account by the user, and are not within the scope of this article.

Material selection can also be used to advantage for epoxy-acid anhydride systems. Acid anhydrides which provide excellent properties are available in liquid or low temperature melting form. Such anhydrides are Nadic methyl anhydride, dodecenyl succinic anhydride and hexahydrophthalic anhydride, marketed by the Allied Chemical Corporation. While these anhydrides are still toxic for skin contact or oral ingestion, their vapors are not nearly as lachrymatic and irritating as the vapors from solid anhydrides. Also, they can be used at or near to room temperature. They are, therefore, generally easier to handle than the solid acid anhydrides.

FIRE HAZARDS, HANDLING AND STORAGE

For the most part, fire hazards with base resins are not severe, since the base resins are less flammable than many other more volatile organic chemicals which are handled safely regularly. Nevertheless, being organic, the resins will burn if ignited. Hence, they should not be used in the presence of open flames. More dangerous from the flammability viewpoint are the auxiliary chemicals used with resins such as solvents, diluents, monomers, and peroxide catalysts. For this reason, volatile, low flash point solvents such as acetone, ketones, benzene and toluene should be avoided wherever possible. For cleaning operations, methylene chloride is equally satisfactory, and is not flammable. Also, non-flammable commercial stripping solvents can be used to advantage. Lower volatility Stoddard Solvent is satisfactory for cleaning liquid resins, mold release, foreign grease, dirt, etc.

Perhaps the resin systems presenting the greatest fire hazards are the polyester systems. There are three danger areas here, namely, the monomer (usually styrene), the peroxide catalysts used for reacting the polyesters, and the potential, explosive reaction between the peroxide catalysts and reaction promoters such as cobalt naphthenate. The styrene or other monomer in a polyester resin

Figure 2. Some articles of safety equipment for use in resin processing (photo courtesy Union Carbide Plastics Co.)

should be treated with the precautions customary for a low flash point solvent, primarily keeping away from heat and open flame areas. Since most polyesters supplied to the end user have 20-35 percent styrene, the as-received resin should also be kept away from excessive heat and open flames. In fact, polyester resins should also be stored in a cool room for the reason that premature gelation of the resin will not occur.

Another safety point which should be observed in the storage of resins is that the resin drums should be grounded.

There is just one rule for the promoter—peroxide catalyst problem—keep them apart. If both a promoter and a peroxide catalyst are used in a system, the proper procedure is to mix either the promoter or catalyst into the resin before mixing in the remaining ingredient. If the promoter and peroxide come together in their concentrated form, an explosive reaction results, and a fire is often started.

Organic peroxides alone are, by their oxidizing nature, usually extremely flammable and under certain conditions may decompose with explosive violence. However, there are differences in the degree and type of hazard associated with various products. The following information on various peroxides has been reported by Lucidol Division, Wallace and Tiernan, Inc.:

Solid Peroxides

Benzoyl peroxide can be stored for long periods at normal room temperatures. However, it burns with tremendous speed and decomposes violently at high temperatures. The violence of the decomposition is dependent on the degree of confinement. Unconfined benzoyl peroxide when exposed to temperatures above 80°C (176°F) will slowly decompose with the evolution of heat and when heated rapidly to 105°C (221°F) it will melt and decompose with a mild puff. Heating over 80°C (176°F) for any length of time, depending on the quantity of material involved, will cause a decomposition of explosive violence if the benzoyl peroxide is confined. Benzoyl peroxide is shock sensitive and will decompose if subjected to heavy shock of frictional heat. The violence of the decomposition is again dependent on the degree of confinement.

Benzoyl peroxide, compounded in certain percentages with camphor, calcium phosphate and calcium sulfate forms non-flammable mixtures. They are not shock sensitive.

Lauroyl peroxide is probably the safest of all the organic peroxides. It is not shock sensitive and it can only be ignited with difficulty. When it does burn, the rate of burning is about the same as that of a solid alcohol.

Cyclohexanone peroxide compounded at 85% concentration with dibutyl phthalate is somewhat shock sensitive in about the same range as benzoyl peroxide. It can be ignited with ease, but it burns at a much slower rate than benzoyl peroxide. In fact its burning rate is very similar to that of lauroyl peroxide.

Paste Peroxides

Organic peroxides are compounded to form pastes in order to improve their safety characteristics and to facilitate their dispersion into the resin systems. In some cases the pure organic peroxides are not acceptable for shipment and they therefore are shipped in diluted forms as pastes.

The paste compounds are less shock sensitive than the pure peroxides and they burn much more slowly. They are, however, thermally less stable than the pure compounds, but the decomposition of the pastes proceeds without the speed and violence associated with the pure peroxides.

Liquid Peroxides

Methyl ethyl ketone peroxide in the pure form is shock sensitive and it must, therefore, be diluted with dimethyl phthalate to a 60% concentration to be acceptable for shipment. The solution may still be shock sensitive. This may constitute a hazard. It is possible for methyl ethyl ketone peroxide to exist in several different structures, some of which are extremely shock sensitive even in 60% solution. Therefore, it is essential that manufacturing and storage conditions be carefully controlled to avoid the formation of these hazardous products.

Commercial t-butyl hydroperoxide is actually a mixture containing 70% t-butyl hydroperoxide, 20% di-t-butyl peroxide, 5% t-butyl alcohol, 4% water and 1% inerts. The flash point (open cup) of this mixture is 17°C (62°F). The liquid is not shock sensitive. It decomposes mildly at 90°C (194°F), but burns rapidly when ignited.

Di-t-butyl peroxide has unusual stability and has even been distilled at a temperature of 108°-110°C (226°-230°F). It is not shock sensitive, but has an open cup flash point of 18°C (65°F). When ignited, di-t-butyl peroxide burns more rapidly than most other flammable liquids.

T-Butyl perbenzoate has a high flash point above 66°C (150°F). It is not shock sensitive, but will decompose rapidly when exposed to temperatures above 105°C (221°F). This liquid peroxide will also burn rapidly when ignited in a manner similar to gasoline.

Cumene hydroperoxide is a mixture containing 72-75% of the hydroperoxide and 25-28% inerts in the form of unreacted alcohol and ketone, and a small quantity of water. The open cup flash point is 80°C (176°F). Cumene hydroperoxide is not shock sensitive and has good thermal stability.

Acetyl peroxide in the pure state is extremely shock sensitive. As a

25% solution in dimethyl phthalate, the shock sensitivity has been reduced to a point where it is acceptable for shipment. However, the solution is still very sensitive to heat and should not be subjected to temperatures above 32°C (90°F). Violent decomposition may occur above this temperature due to self-accelerating decomposition. The open cup flash point is 45°C (113°F). If ignited, the solution burns vigorously.

Handling and Storage of Peroxides

The following precautions should be observed in the storage and handling of peroxide catalysts:

1. Peroxide storage buildings should be in isolated locations. They should be used exclusively for storage of organic peroxides.
2. Liquid organic peroxides should not be stored in the same buildings with solids or pastes.
3. Buildings should be of fireproof construction.
4. No sources of heat or electrical connections should be provided. If light sources are necessary, exterior lights should be provided which will shine through the door openings.
5. Buildings should be conspicuously posted "Flammable Storage—Keep Fire Away".
6. No smoking should be permitted in or near the buildings.
7. The area around storage buildings should be kept free of all combustible material.
8. The buildings should contain organic peroxides packed only in the original shipping cases.
9. Dispensing or weighing out of peroxides should not be permitted in the storage buildings.
10. Storage rooms should be kept cool—60-70°F.
11. Peroxide container caps (liquids, especially) should not be replaced with another cap, as safety caps are commonly used in packing these materials.

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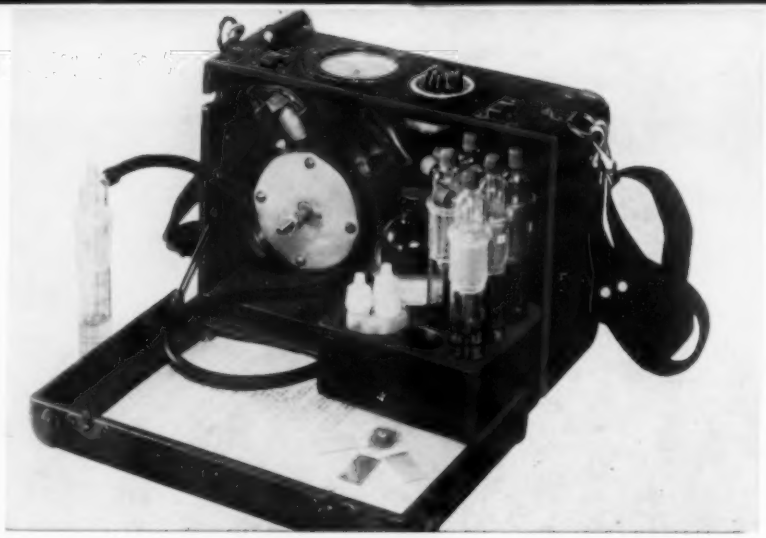

Figure 3. Detection kit for detecting TDI vapor level in diisocyanate resin processing areas (photo courtesy Mine Safety Appliances Co.)

Acknowledgments

The helpful cooperation of the following persons and organizations in preparation of this material is hereby acknowledged:

P. J. Teliha and N. G. White, Shell Chemical Corporation; A. G. Butler and E. A. Barr, Union Carbide Plastics Company; E. N. Dorman and W. Ibsen, Ciba Products Corporation; E. Grandjean, Swiss Federal Institute of Technology; W. C. Jenner, Hysol Corporation; Electron Products Div., Marshall Industries; C. H. Sanderson, Mine Safety Appliances Company; J. L. Formo, Minneapolis-Honeywell Regulator Company; J. Delmonte, Furane Plastics, Incorporated; C. H. Rybolt and A. I. Andrews, Lucidol Div., Wallace and Tierman, Inc.

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SOME RECOMMENDED PROTECTIVE CREAMS AND LOTIONS FOR USE WITH RESINS

	Material	*Supplier*
1.	Various SWISH Formulations	Industrial Cosmetics Laboratory 1654 Euclid St., Santa Monica, California.
2.	Kerodex	Ayerst Laboratories, 22 E. 40th St., New York 16, N. Y.
3.	West Disinfectant 411	West Laboratories, 42-16 West, Long Island City, N. Y.
4.	Ply #9	Hysol Corporation, Olean, N. Y.
5.	Silicare	Revlon Co., New York, N. Y. (or local drug store)
6.	Covicone Cream	Abbot Laboratories (or local drug store)
7.	Silicote	Arnar-Stone Laboratories, Inc. (or local drug store).

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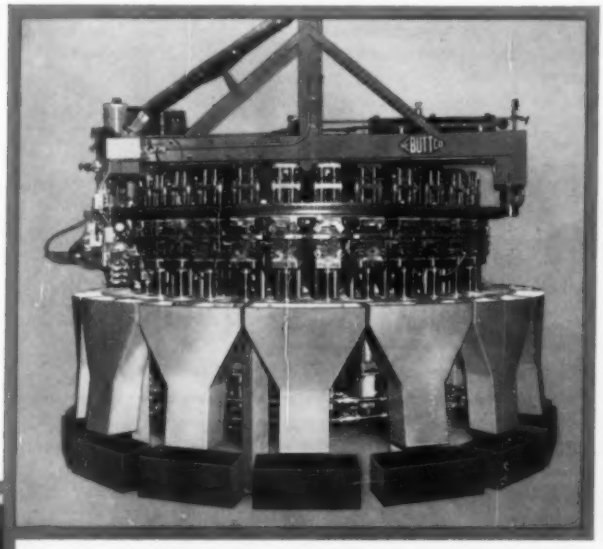
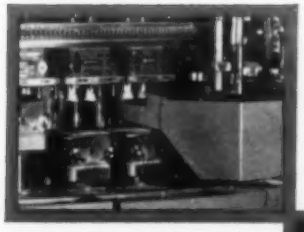
Molds Thermosetting Closures FAST





Molds are progressively opened, charged with compound, and closed under pressure for curing as feeding arm revolves around machine.

Cam-actuated rotating wheel automatically unscrews closures as molding cycle is completed.

NEBUTTCO

The thirty stations on this Nebutteo Rotary Press provide high speed, continuous molding of large or small quantities using any free-flowing thermosetting compound in low cost, single or double cavity molds. Providing the closures are the same color and similar in section, as many as three different molds can be used in the machine at one time.

The compound is hopper-fed, and precision metered through the rotating feeder arm. Machine eliminates sorting problems, because stations eject parts into separate metal chutes. Production cycle can be varied and the temperature in the mold holders can be individually adjusted if required.

The machine is available in one model — the thirty-station press illustrated. This machine is easy to install and maintain, and is adaptable for many applications.

For more information please contact

NEW ENGLAND BUTT COMPANY
Division of Wanskuck Co.
304 Pearl Street, Providence 7, Rhode Island

DOW PLASTICS TECHNICAL FILE

OPTICAL ENGINEERING DESIGN USING CRYSTAL CLEAR ZERLON

In designing plastic objects whose primary function is the refraction or transmission of visible light, refractive index of the plastic is an invaluable tool in engineering design. Refractive index of any material is, of course, the ratio of the velocity of light in a vacuum to the velocity of light in the material in question. That is,

$$n = \frac{\text{Velocity of light in vacuum}}{\text{Velocity of light in material}}$$

While refractive index is normally used for identification and quality control of plastics, it may also be applied as design data for engineering purposes.

Obviously, light which strikes a highly transparent plastic normal to the surface (at a right angle), will pass through without deviation (Fig. 1a). As the plastic is tipped (Fig. 1b) the transmitted ray is refracted ("bent") as it leaves the plastic-air interface.

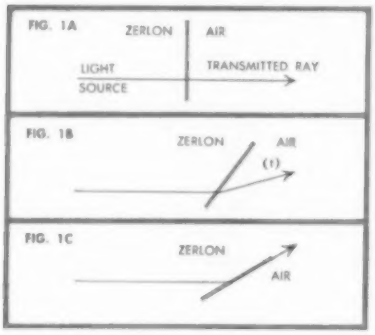


Fig. 1a—Light ray normal to surface.
Fig. 1b—Light ray striking surface obliquely.
Fig. 1c—At critical angle, light is reflected back into the plastic.

As the incident angle is further decreased, an angle is reached at which the ray will not pass into the air, but instead will be reflected into the plastic ("piping" action). (Fig. 1c). This is the critical angle. The critical angle is the incident angle whose sine is the refractive index of air divided by the refractive index of the material in question.

Consider this problem (Fig. 2): to design a radio dial face using Zerlon® crystal-clear, non-yellowing Dow molding plastic. The dial will be illuminated uniformly by interior light, i.e., light "piped" through the dial face from a concealed source. The dial thickness must be sufficient to withstand normal use, but can be *no greater than* 0.115".

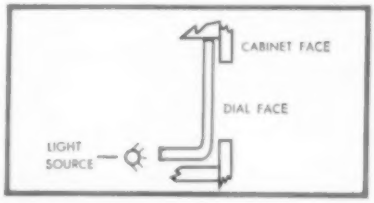
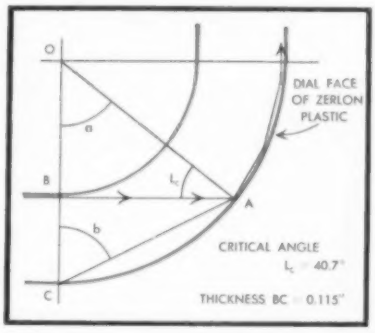


Fig. 2—Design problem.

Light from the source must strike the bend in the dial molding at greater than the critical angle in order to be "piped" along the dial face. For this problem, Zerlon was chosen because of toughness, easy moldability, and transparency. Since the refractive index of



Zerlon is 1.533, its critical angle is 40.7° (Sine $L_c = \frac{1.0}{1.533} = 0.652$). Therefore, the minimum radius of the bend which will assure maximum light on the dial face (using thickness of 0.115"):

Inside Radius = 0.215 in. minimum
Outside Radius = 0.215 + 0.115 = 0.330 in. (minimum)

The molded dial face should also be given a 2°-3° taper for maximum face illumination. The final design will be as in Fig. 3.

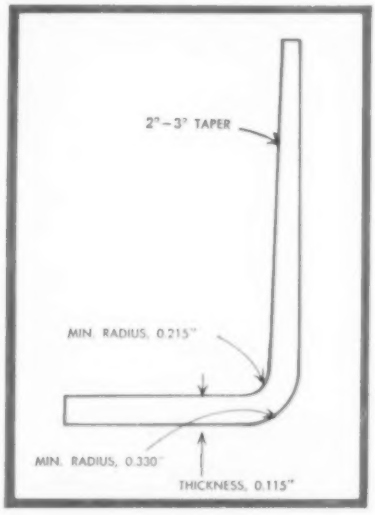


Fig. 3—Design solution.

Continuing studies by Dow Plastics Technical Service Engineers are providing valuable data, of the kind above, to assist designers and plastics engineers in all phases of plastics technology. For detailed information on these studies write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1731EX3.

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SPEAKING OF EXTRUSION

What Price Output

Economies may turn out to be exceptionally high costs, when you modify your extruders

The extrusion papers presented at the 17th Annual Technical Conference (ANTEC) this year were of outstanding quality and reflect the sophistication of knowledge being applied in the design and development of extrusion machinery throughout the world. One of the outstanding meetings of this ANTEC was the extrusion panel and the questions and answers presented. It is apparent from observation of these meetings and papers that the technology of extrusion is becoming more and more specialized. This is, of course, of considerable importance to all involved in extrusion fields, both from the manufacturers' and designers' standpoint as well as the converters'.

High Speed Extrusion—Weigh Carefully

While much of the new knowledge that has been developed is steadily increasing the productivity and quality for the customer and consumer, there are certain aspects that must not be overlooked. For example, the fine paper presented by Bruce Maddock of Union Carbide Plastics Corp. was aimed primarily at high outputs of polyethylene materials where high temperatures and outputs are desirable. Such information will undoubtedly improve the productivity of existing paper coating or film casting units presently in existence or being built for the future.

On the other hand, such high temperature output would be unsuitable for most polyethylene pipe producers. They must be able to extrude at much lower stock temperatures in order to maintain uniformity of size and shape. In a few isolated cases elaborate take-off and cooling devices have been employed in order to obtain higher outputs. The economy of such equipment can only be determined by the user. There has been considerable talk in the industry of running extruders at much higher than the conventional 70 to 100 RPM, that has been common for the last 5 to 10 years. This is certainly in the best interests of all, provided the materials can be extruded in a form compatible with the converter's take-off equipment.

The danger of high speed extrusion for all lies with the fact that in many cases high outputs at high stock temperatures simply cannot be used until some better method of handling the molten plastic has been devised. A few years ago it was considered common practice to expect outputs of 400 to 450 lbs./hr. of high impact polystyrene sheeting from a 4½" 20:1 extruder. Today, with new developments in screw design and some improvement in take-off equipment and "know-how", it is possible to attain 640 to 700 lbs./hr. output of equally good quality on the same 4½" 20:1 extruder.

In the case of polyethylene film output in some plants has increased from 60 to well over 100 lbs./hr. on a 2½" extruder. Again changes to take-off equipment were necessary. Such progress was not achieved without considerable effort on the part of the material supplier, his customer, and the machinery manufacturer. It is not improbable that further progress in this direction will be made and outputs well in excess of these may be achieved as the development continues. Such developments have allowed plastics producers to increase their productivity without any major change in equipment and at reasonable cost.

Similar progress is constantly being made in other areas of extrusion and is, of course, most desirable where long term continuous production is practical. This is fine for a refrigerator sheeting plant or pipe producer with a large quantity of machines who can run one or two sizes for an extended period of time, but what about the custom extruder who may have two or three different set-ups in one day? In the case of this type of work, high speed extrusion equipment may not be to the best interest of the user because he cannot afford to experiment with all the various shapes and materials being handled in his production schedule. The mere fact that it takes from ½ to 2 hours, depending on size, for the average extruder to reach equilibrium would cause considerable expense and offer no real economy. The custom extruder then must have a much more versatile machine to meet his needs.

Highly-versatile extrusion equipment is available from most equipment manufacturers at moderate additional cost. Such features as extra cooling capacity, induction heating, specialized screw designs, quick opening gates, valves for pressure control, etc. are some of the more important features available. Good instrumentation and reliable heaters are a must for any extrusion application. Without such aids it would be impossible to duplicate the necessary conditions from one run to the next. Diligent use of these tools will reduce the need of long runs to get "on gage" or to duplicate the results of previous successful runs.

Scale-Up Considerations

There has been much talk recently regarding HP capacity of an extruder. This is truly an important consideration and is directly related to the output capacity of any extruder. We must also consider torque which is the most important consideration but is often times not seriously considered. The formula

$$HP = \frac{\text{Torque (foot lbs.)} \times \text{RPM}}{5252}$$

shows that HP is a direct function of speed when torque is constant, and when torque increases as it often does when extruding materials of higher melt viscosities or specific heat, then, speed or HP must change in order to turn the feed screw. Torque is the first consideration in gear design and is the basis for size of the reduction unit. Sufficient torque must be available in order to shear the material. Once an ample torque valve is determined for a specific product we have only to decide what speed we want to turn the screw in order to size the drive.

From the above explanation of torque it can be readily seen that in order to extrude a wide range of materials it is necessary to size the extruder transmission for that material requiring the highest torque.

Let's now examine the difference in capital equipment costs to scale-up from a high speed 3½" extruder to a conventional speed 4½" extruder. In either case, the drive cost will be the same because it is necessary to have ample horsepower. Let's then say for a 3½" extruder, a speed would be set for a range of 200-20 RPM using an eddy-current type coupling and AC motor. The 4½" extruder would have a speed range of 70-7 RPM using the same eddy-current type drive. The cost of a 75 HP drive would be approximately $5,500.00 for either extruder. The cost of the 3½" extruder would be approximately $13,000.00, making a total cost of $18,500.00 for a 3½" high speed extruder and drive. The cost of a 4½" machine would be approximately $16,000.00 making the total cost $21,500.00 including the drive. Or a difference of $3,000.00 for the larger 4½" extruder which we will assume will produce the same amount of product and would amount to approximately 16% increase in investment. The larger machine would have a much larger potential output as the technology of extrusion progresses. The important point is that expected output could be achieved without risk and possible inability to meet customer's volume requirements. The 4½" machine, of course, has a much improved life due to running at lower speeds. While no exact data has been developed for wear vs screw speed of an extruder, there is some evidence to indicate that screw wear rates are more than directly proportional to periferal speed. Thrust bearing life is inversely proportional to speed and will decrease as speed increases. **Caution:** do not change screw speed range or HP of an existing extruder without first consulting the extruder manufacturer.

Another consideration in favor of the conventional speed machine vs the high speed machine for custom extruders is that some materials such as rigid PVC compound types one and two must be extruded at very low screw speeds and high torque. The 3½" extruder mentioned above would have to be equipped with V-belts and sheaves, or some other ratio changing device in order to operate in the ranges of speed required for rigid PVC compound. The 4½" machine mentioned above would be able to run in this speed range without adjustments other than that of the eddy-current coupling output speed. Many of the cellulosic materials fall in a speed range slightly higher than PVC's but again require torques considerably above those required for low density polyethylene and impact polystyrene.

To summarize, in choosing an extruder, first define the job which is to be done. This can best be done by the extrusion engineer who will determine his company's requirements and by the sales engineer of the extruder manufacturer, who has considerable background both from work performed in his company's laboratory and other customer experience. Such consultation can often result in a true savings to the buyer. There are many economies that appear on the surface that soon run into exceptionally high cost once the extruder is installed and performance is less than expected. On the other hand, true economies can be realized through upgrading of extrusion and take-off techniques.

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"Heating Capacity Limitations of Extruder Screws" by B. H. Maddock, Union Carbide Plastics Co., 17th ANTEC.

Edited by **Bruce H. Maddock**
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REINFORCED PLASTICS

Application of Glass Reinforced Polyesters to Large Structures

A discussion of reinforced plastics in large structural beams used under mildly corrosive conditions. A successful application in power plant service is described

Of the two basic methods of fighting corrosion, material selection and structural design, the former is more effective. Design is called in where completely adequate materials are not available. Although the good chemical and physical properties of polyester laminates have been known and widely used for some time, the application of these materials to large structural members is a recent development. In one such application, a large West Coast power company has installed reinforced plastic frames for the water intake screens at three of its steam stations.

Glass reinforced plastics are currently being used in the fans and grids in cooling towers, in submarine superstructures and applications in underwater weapons.

Water Intake Screens

Just recently, several of the water intake screen assemblies mentioned above, which had been in service for two years, were removed for inspection. After cleaning the various marine growth and debris from the structure, it was noted that, although barnacles and other forms of marine life cling to the structure in much the same manner as any other submerged object, the secretions, often deteriorating or corrosive to metals, have no apparent effect on the surface of the plastic.

Examination of the assembly showed no stress cracks, worn areas, pitting, scaling, or other deterioration in the plastic sections. (*Figures 1, 2 and 3.*)

Figure 1 shows an intake screen assembly, one of a pair in each channel. The frame is of glass reinforced polyester (GRP) while the wire cloth, fasteners and gussets are of 1010 Everdur bronze. The rollers are micarta. Other similar assemblies incorporate GRP guides which slide in coated concrete grooves. The hydraulic differential through the screen automatically controls raising and cleaning of each screen.

Figure 2 gives a closer view of the water intake screen assembly showing the fasteners joining the beams and attaching the screen to the framework. The assembly has been designed so that the screen can be replaced.

Figure 3 shows a view of the bin which catches the debris sprayed from the screen.

The woven screen of 1010 Everdur bronze wire, 0.135 inch in diameter, was found to be reduced in some areas to between .030 inch and .040 inch by corrosion and erosion (70% of the original diameter or about .047 inch per year). Admittedly, this is an isolated example. Some similar units of steel in like environments have been known to last as long as 10 years with little or no maintenance. However it is doubtful that a plastic structure could be sold to replace a steel structure in a situation such as this; that is, until the pound-for-pound price is competitive.

The water intake screen assemblies are subjected to varying stress levels due to tides, weather, and debris partially blocking the screen. The water is highly aerated, tending to accelerate corrosion. The velocity of the water is between two and seven feet per second and the presence of sand and other abrasive particles does not allow a sufficient oxide layer to coat the metal surfaces.

Development of Plastic Structural Members

Much of the high strength of CTL's reinforced plastic structural members

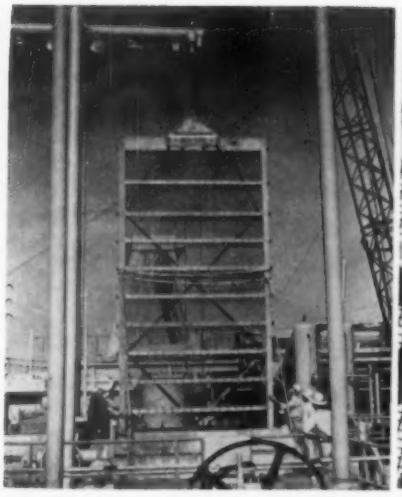

Figure 1. Water intake screen assembly with glass reinforced polyester frame and bronze wire cloth

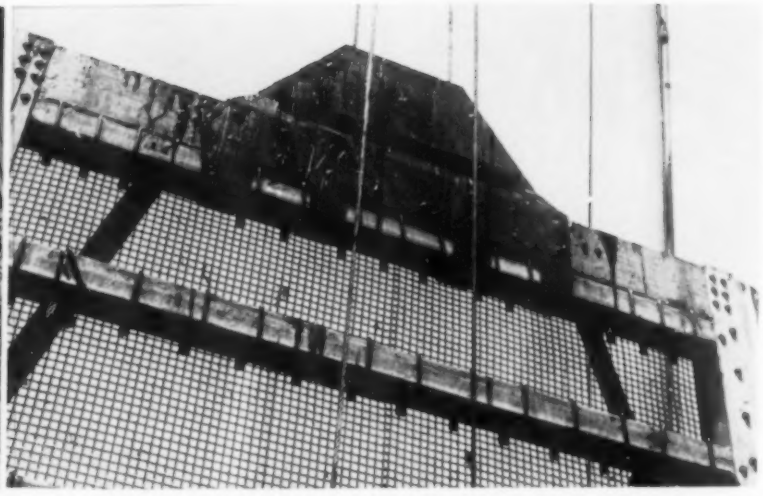

Figure 2. A closer view of the screen assembly, showing the fasteners joining the beams and holding the screen to the frame

can be attributed to the unidirectional orientation of the glass fibers. This unidirectional quality permits the fabricator to modify the physical properties, tailor making the part to the job. For this reason, it is more proper to advertise a range of physical properties for a given shape.

Early in the development period it was thought that nearly optimum physical properties could be obtained using relatively inexpensive tooling. After testing a number of specimens, it became apparent that theoretical optimum properties could be realized only with more elaborate molding equipment. The only values that were found to remain constant with both small and large samples were tensile strengths which were always at least 90,000 psi. By modifying the build-up, values of 150,000 psi could easily be obtained. The values in compression and bending were far more erratic at first, and only after a long period of study and evaluation were they increased and stabilized. Early compression values were as low as 35,000 psi, while bending tests produced failures at from 40,000 to 50,000 psi. Since that time, all the values have been increased to a considerably higher range, tension capacity, however, still dominating flexure and compression. For this reason, shapes and structures are designed to take advantage of the high tensile properties and to minimize the stresses in compression. This can often be a problem when one is designing a part to mate with other existing parts.

As in most reinforced plastics, and other heterogeneous materials, for that matter, some difficulty is encountered in producing part after part with identical properties. The variables responsible for this often originate in forming the glass fibers, manufacturing the resin, or when the two are joined. Much of the variation can be eliminated by inspection of the raw material before molding, and by use of well designed molding equipment, manned by operators and fabricators of a high caliber. The rejection rate, even at the earliest stages of production, has been kept to under 6%.

Although every size and shape in a steel handbook cannot be readily matched at this time, it is possible to select certain industrial areas and fabricate beams to substitute the more commonly used metal sections, and offer to custom-mold, often, at a savings of material, other pieces required. Besides, the most lucrative fields at this time are those applications which have unique problems of corrosion and weight, and often require funding by supplier or customer to develop the specific part needed. In promoting the use of reinforced plastic structural members for projects involving the government, a considerable amount of difficulty arises in convincing people that a plastic material can do the job. Not unlike the tremendous barrier that had to be overcome some years back, when plastics were offered as a solution to the high temperature problems of the missile and aircraft industry, approval must often go first through the engineering concern, followed by the prime contractor and, lastly, by the government agency. Acceptance then could be considered as the biggest present problem. Service life, maintenance and replacement parts must be observed over an extended period of time in order that the material might sell itself.

Comparison with Other Materials

Plastic structural material must be compared with various other structural materials, regardless of how dissimilar the properties might be. Welded fabrication of mild steel, for instance, generally costs about 40 to 50 cents per pound, much less than the glass reinforced plastic, even in the raw form. However, the same structure requires only about 30% reinforced plastic by weight. Although the cost of the reinforced plastic

Figure 3. A view of the bin which catches debris sprayed from the screen

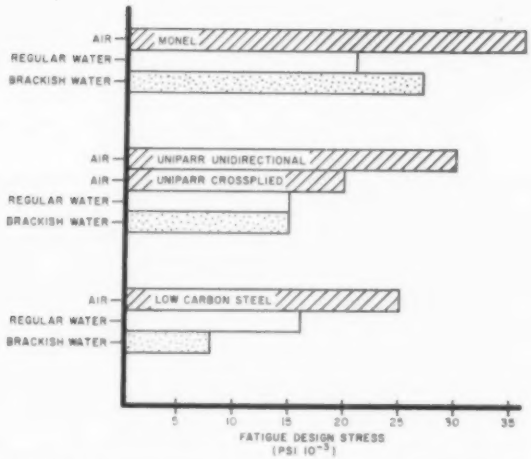

Figure 4. Comparison of fatigue design stress in various environments for Uniparr glass reinforced polyester, steel and Monel

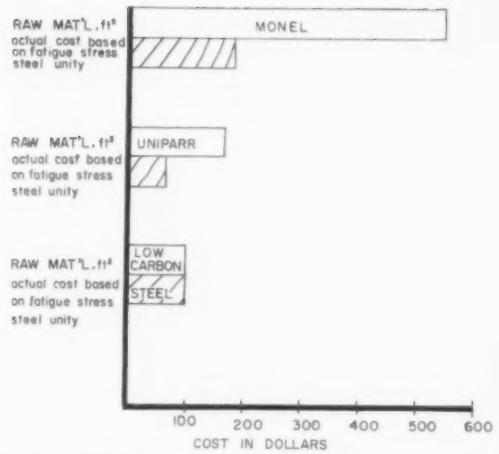

Figure 5. Relative costs of Monel, Uniparr glass reinforced polyester and low carbon steel. Plain bar represents cost per cubic foot, crosshatched bar, cost to handle equivalent fatigue stress in brackish water

structures still may be higher, the additional cost can be more than justified by the superior properties, in most cases.

Under ordinary conditions where structures will not be subjected to corrosive media such as salt or fresh water, design stresses for the standard reinforced structural plastic members can be 20,000 psi, generally similar to those for structural steel. The weight of the plastic part will be approximately ¼ the weight of the steel part. The only major property where reinforced plastic will not compare favorably with metal is the modulus of elasticity. To date, this has not been a serious problem, even when existing metal parts were replaced. Based on the accumulated data, the plastic structure can be expected to last at least four times as long as the metal structure. This estimate must be considered conservative, as there is much data supporting an almost indefinite service life.

Brackish water, for example, seriously reduces the strength and fatigue limit of the metallic materials (*Figure 4*). Consequently, the design engineer must use more material. As a more specific example, consider a structure required to take a given constant load under sea water. Reinforced plastic members with a density of 0.0615 lbs./cu. in. are available for design loads of 30,000 psi in brackish water. Carbon steel, however, has a density of .284 lbs./cu. in. with a design load of only 6,000 to 8,000 psi under salt water. Thus, the reinforced polyester structure would weigh approximately ⅛ as much as the steel part, would cost less to ship, and it would require much less handling equipment. A similar comparison for fatigue design loads may be made with the aid of *Figure 4*, where fatigue design stresses are shown for various environments and Figure 5, where relative costs per cubic foot and relative cost to handle a given fatigue stress in brackish water are compared.

The corrosion-resistant alloy, Monel, which exhibits higher physical properties than structural steel is in approximately the same price range as reinforced plastics. The performance of the alloys, although superior to steel, will usually be affected proportionately by similar conditions.

Fasteners must also be considered in comparing reinforced plastics with metals. In promoting reinforced plastic structures, fasteners can be either a help or a hindrance. Since joints are very often the weakest part of the structure, they must be given careful consideration. In many large structures, there is not sufficient surface area to use adhesives. In this case, high strength corrosion resistant bolts must be used. Although expensive, this method is often cheaper than welding an equivalent metal structure.

In one case where a 2′ × 10′ framework was called for, the fastening problem was eliminated. New tooling was designed simply to mold the assembly in one piece.

Conclusions

In many cases where corrosion by brackish or fresh water is a problem, large structures of glass reinforced polyester may replace steel with a saving of both initial and handling costs.

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Adopted from a paper presented to an SPE Regional Technical Conference, San Francisco, Calif., Oct. 5, 1960

Edited by
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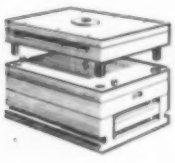

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MOLDMAKING

The Importance of Good Fundamental Mold Design

Molding operations, whether small or giant, have as their motive in business—financial gain, else the operation would cease to exist. Competition in the injection molding business is steadily increasing and if a company properly prepares itself to meet competition, it is necessary for that company to periodically study the cost of each segment of the entire molding operation toward more economical and more efficient production of their molded products. Thorough scrutiny should also be given to all purchases of production facilities such as molds, injection molding machines and allied equipment to be certain those purchases provide them with the molds and equipment most satisfactory to their operation and will provide maximum efficiency and economy when placed in production.

When it is considered that the procurement of a single injection mold represents a capital investment ranging from $2,000 to $3,000 to as high as $40,000 to $50,000 or higher, such an investment makes it necessary that the mold be an efficient and economical operating mold. Insufficient emphasis has been placed in the past by some molders on the operating efficiency and economy of their molds. Most molding companies have been so engrossed in getting molds designed, getting them constructed and sample parts produced in the shortest period of time, they have overlooked the important factors of long term efficiency and economy or operation of their molds in production. Many molders are discovering that the cost of attempting to operate on a production basis an ill-designed, poorly built or inefficient mold is ofttimes more expensive than the initial capital investment in the mold.

In the injection molding business there are five interdependent factors which are considered necessary for the efficient and economical production of satisfactory molded items.

1. *Good* Part Design
2. *Correct* Plastic Material Choice
3. *Proper* Mold Design
4. *Efficient* Molding Equipment
5. *Experienced* Molding Technique

There is a correlation between the words above which are italicized and the underlying factors of success for those in the injection molding business.

Before a mold can be properly designed, the design of the part to be molded should be in its final form, and the choice made of the correct plastic material to be used. This is not always the case, however, the 1, 2, 3 order as listed above is preferred.

The role of a mold design engineer, though primarily that of actual designer of the mold, ofttimes, by necessity encompasses the entire molding operations as set forth by the five factors listed. A mold may be properly designed and constructed for a high degree of efficient performance but its efficiency can be impaired should any one of the other four factors be sub-standard. The sphere of influence and concern of the mold design engineer must therefore extend beyond that of mold designing.

When a new product has been designed and the choice of material has been made for the product, the drawing of the part to be tooled is placed in the hands of the engineer for design of the plastics mold. Four (4) fundamental factors should be considered prior to initiating the design of the mold.

1. A study of the design of the part to be molded should be made to determine if the design of the part can be simplified in a manner to facilitate the mold design, the mold construction or the molding operation, without materially effecting the finished part. The mold designer should familiarize himself with the end-use characteristic and required properties of the part to be molded. He needs to determine if the part is to be functional or decorative or a combination of the two. He needs also to know whether the part is to be an enclosed or an exposed part, and if it is to be part of an assembly, with what and how. The wall sections should be studied toward uniformity of thickness and the avoidance of abrupt sectional changes in wall thickness wherever possible. The design engineer needs to thoroughly study the dimensions and tolerances given to the part and have liberalized as much as possible any unnecessary or unreasonable tolerances. Tapers and draft angles should also be clarified at this point. A look into

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the post molding operations often suggest minute changes that can be made to the part and eliminate the expense, time and potential damage of secondary handling. In essence, the initial job of the mold designer is that of reviewing the work of the part designer and making such changes to the original part design as to render it moldable.

2. The time to select the plastic material for the part to be produced is before the mold design is made. This is not always possible, but it is well to bear in mind that after the mold is built, mold modifications or replacement of mold components to allow for shrinkage variables of different plastics are expensive, time consuming and occasionally impossible. Certain plastic materials have their particular molding characteristics and the design of each mold should be made to accommodate these characteristics in order to obtain a high degree of efficiency from the mold when it is placed into production. Generally, the designer of the part to be molded selects the plastic material he feels is best suited for the particular application. It is always well for the mold designer to review the material selection before starting the design of the mold.

3. A determination should be made as to the most satisfactory method by which the part can be molded. A mold designer should consider the many different injection molding processes available and find the one most suitable for efficient and economical production. He should study the part to determine if valve gating, impact molding, sequential impact molding, hot-runner or runnerless molding, or a conventional runner system is the process most suitable for producing the part. Design of the mold is occasionally limited to the accommodations of the production facilities of the plant or custom molder for whom the mold is being designed, even though those facilities do not provide the most feasible method for producing the part. It is well to constantly bear in mind that there is always one BEST method for molding a part when all methods have been properly evaluated.

4. The mold design engineer should determine the mold construction features and factors prior to performing the mold design. The paramount question to be answered is the durability requirements of the mold. This is easy to determine if it is known whether the mold will be a long-run permanent type mold or a limited production mold. When the extensiveness of life required in a mold depends upon the selling success of the product to be produced, it is wise to design and construct a mold for better than average durability. The strength requirements of a mold and components of the mold are factors for consideration in the planning stage of a mold design. The economy of mold construction, economy of operation and economy of mold maintenance are important additional factors. Often in the design of a mold there is overlooked the factors of convenience of operation in production, or the convenience of mold installation and mold removal from a machine or the convenience of assembly and disassembly of the mold for maintenance purposes. These can be big factors in the profit picture of a molding operation and must receive study by the engineer at the time of the mold design. The materials of construction of a mold should be considered and a decision made as to whether standard or prehardened mold plates will be used in the mold. Likewise, the mold designer must determine the most suitable material to be used in the cavity and core and ascertain the method by which these parts will be made. A study of the auxiliary or outboard equipment requirements should be made with respect to their positiveness of operation, convenience of installation, and their ease of disconnection for mold maintenance.

Good fundamental mold design is the key to good operating molds in production. Good operating molds are characterized by their ability to produce satisfactory molded parts on an efficient and economical basis. From such molds may be produced uniform parts in continuous cyclic production. Molds of this order render satisfactory tool life; require a minimum of mold maintenance; are safe and convenient for operating personnel and present a minimum hazard of tool damage. Good designed molds and good operating molds are slightly more expensive to procure than mediocre molds but such additional expense is justified by their efficiency in operation.

—■—

Edited by **Ernest J. Csaszar**
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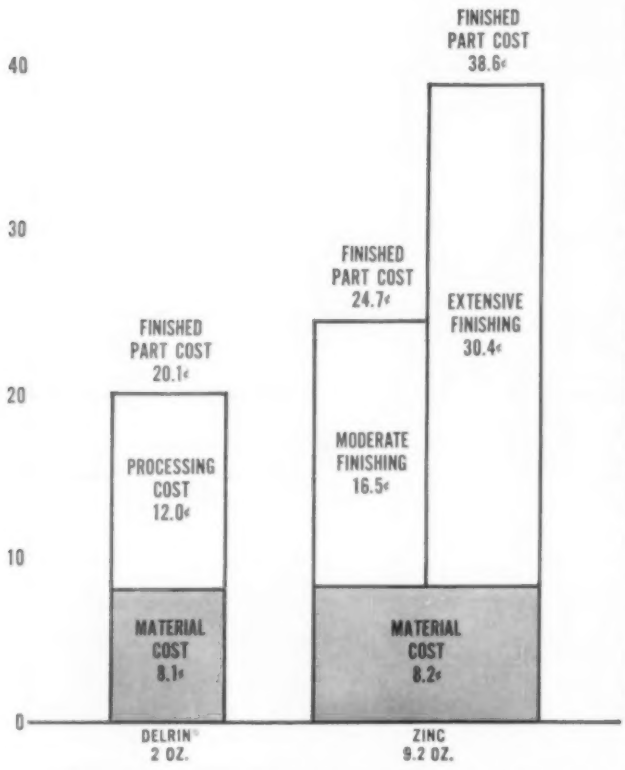


Comparison of finished-part cost and all component costs of a part made in DELRIN and die-cast zinc is shown above. Note lower raw-material costs of DELRIN (8.1¢ vs. 8.2¢) and wide difference in total finished-part costs when zinc part requires moderate or extensive finishing (20.1¢ vs. 24.7¢ and 38.6¢)—dramatic proof of your strong competitive position with DELRIN in metals-replacement market today!

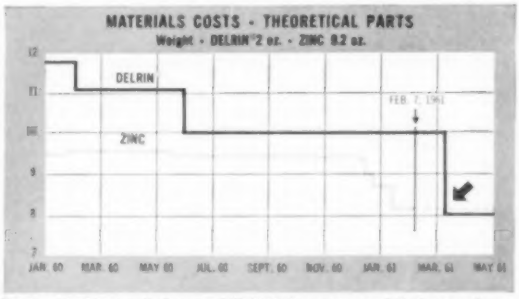
For full information about properties, molding characteristics and applications of DELRIN write: E. I. du Pont de Nemours & Co. (Inc.), Dept. SP-3, Room 2507D, Nemours Building, Wilmington 98, Delaware. *In Canada:* Du Pont of Canada Limited, P.O. Box 660, Montreal, Que.

POLYCHEMICALS DEPARTMENT

65¢-per-lb. price permits lower materials cost than zinc on an equivalent volume basis—plus usual high savings in fabrication costs

On February 7, 1961, Du Pont announced the price reduction of DELRIN acetal resins by 15¢ per lb., from 80¢ to 65¢, creating an unprecedented sales opportunity for you in industries that use metal in cast or molded form. For the first time, DELRIN gives you an advantage over zinc on a *raw-materials-cost* basis for an equivalent part! The new price was effective March 7.

Naturally, your cost advantage becomes even greater on a finished-part basis. When either moderate or extensive finishing operations are required for parts of zinc or aluminum, parts of DELRIN can be made for substantially less (see chart left). Result: Whenever the properties of DELRIN fit the application, you have a sharp sales edge in bidding against any zinc or aluminum die casting that requires finishing, and almost all do. The properties of DELRIN are right for a large segment of applications now being made of die-cast metals.



Cost reductions of zinc and DELRIN announced between January 1, 1960, and February 7, 1961, are reflected in this chart. It shows raw-material costs for a theoretical part requiring 2 oz. DELRIN or 9.2 oz. zinc. Note breakthrough point in March.

This cost reduction for DELRIN is consistent with Du Pont's policy of lowering the prices of its versatile engineering materials whenever possible to help you expand your business. This trend in pricing is expected to continue.

Du Pont's problem-solving engineering materials:

ALATHON® polyethylene resins **DELRIN®** acetal resins **LUCITE®** acrylic resins **ZYTEL®** nylon resins

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SPE JOURNAL

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Foamed Plastic Particles — Versatile New Materials

This article describes the preparation and properties of foamed plastic particles—a brand new aspect of the fast-growing foamed plastics field. Foamed plastic particles are tiny, discrete, cellular or porous spheres, made of fully polymerized resins. Either open or closed cell in structure, these particles are extremely low in density and can be prepared in controlled sizes ranging from a few microns in diameter on up to hundreds of microns in diameter. Like foamed plastics in bulk form, these particles can be synthesized from virtually all types of resins and can be literally chemically tailored to suit end-use requirements

Betty Lou Raskin

The Johns Hopkins University, Radiation Laboratory

The Johns Hopkins University Radiation Laboratory was asked by the U.S. Air Force to try to prepare a new type of smoke—one which has a slower settling rate than any of the existing smokes, is relatively harmless to the personnel and equipment, and can be readily colored for signaling purposes.

First, the properties and methods of preparation of the smokes which were to be improved were studied. It was found that most of the commonly used smokes were composed of particles approximately one micron or less in diameter, made from materials such as phosphorus pentoxide, carbon, titanium tetrachloride, zinc chloride, and light oils. The average density of these smoke materials was found to be about 2 gm./cc.

According to Stokes Law, $V = \frac{2\,r^2\,pg}{9\eta}$

where

V	=	velocity of fall in still air in cm/sec. at 18°C.
r	=	particle radius in cm.
p	=	density of smoke material in gm./cc.
g	=	acceleration due to gravity—980 cm/sec.^{2}
η	=	viscosity of air at 18°C.—1.83 x 10^{-4} poise.

One micron diameter particles of these smokes were found to have an average fall-out rate of about 21.3 cm./hr. Assuming that the atmospheric conditions remain constant, it is apparent from this equation that the settling rate of a smoke composed of particles of a given size can be reduced only by the amount by which the density of the material from which the smoke particles are made is decreased. For example, if a smoke could be made from one micron diameter particles having a density of 0.016 gm./cc. (1 lb./cu. ft.) instead of 2 gm./cc. (125 lb./cu. ft.) the theoretical settling rate of the smoke could be reduced by a factor of 125 times.

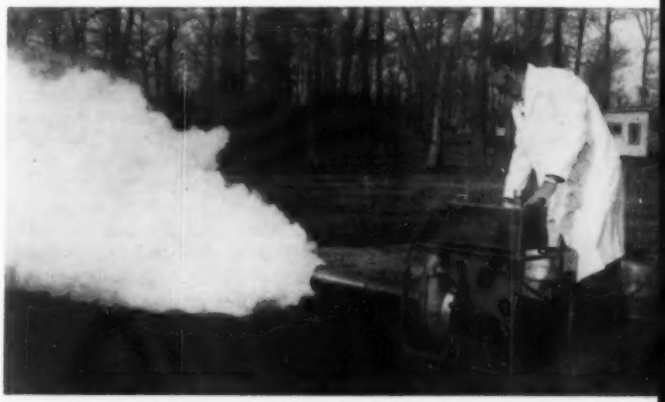


Figure 1. Smoke composed of urethane foam particles being produced by a gas turbine generator

Preparation of Foamed Plastic Smoke

Our problem, therefore was to find an extremely low density material which could be prepared in particulate form. As a result of a literature search on this project, it was found that no smokes composed of particles of materials having specific gravities appreciably less than one had even been reported. It also was apparent that of all low density materials, natural and synthetic, solid and liquid, foamed plastics seemed to be the most logical materials for this job. Initially, small quantities of cellular phenolformaldehyde particles were generated into the atmosphere by means of a two-nozzle spray gun mixing system, using a phenolic foaming composition and an acid catalyst. It soon became apparent that a thermomechanical system was needed so that smaller droplets could be produced and mixed more efficiently.

After an extensive series of laboratory experiments and field tests, it was found that a modified gas turbine was one of several satisfactory means of dispersing smokes made of these low density synthetic particles (*Figure 1*). In this apparatus a special foam-forming plastic composition was injected into a hot gas stream where it was "atomized", cured, and then dispersed as fully expanded, polymerized particles. Almost any resinous composition that can be foamed (and all that can be foamed in place) offer potential for use in smoke production. Both polyether and polyester resin—based urethanes, as well as modified and unmodified phenol-formaldehyde resins have been found to work particularly well.

When an expandable phenol-formaldehyde resinous composition was introduced under pressure into the stream of hot gases in the gas turbine generator, a dense pink smoke was produced. The pink color was characteristic of the phenolic foam. When a urethane foam prepolymer system was fed through the generator, a dense white smoke having the characteristic color of an unpigmented urethane foam was produced.

Particles of each of these types of foamed plastic smokes were collected in an electrostatic precipitator 75 feet from the generator and then microscopically examined. They were found to be spherical in shape and definitely cellular in structure. (*Figure 2*). This, of course, was further proof of the fact that smokes composed of cellular plastic particles had been produced from each of two basically different types of expandable resins. Subsequent experiments indicated that it was not only possible to prepare smokes from a variety of resin types, but also to control the sizes of the particles in these smokes by making appropriate changes in the foaming composition and reaction conditions.

By means of this development it is now possible to prepare smokes with densities equal to or less than that of air (0.0012 gm./cc.). Large particle size smokes having slower fall-out rates than smaller diameter particles of high densities can also be produced. For example, smokes composed of 10 micron diameter particles of a 0.0016 gm./cc. phenolic foam have a theoretical settling rate of 1.7 cm./hr.; whereas, smokes composed of one micron diameter droplets of a 2 gm./cc. density fog oil have a computed fall-rate of 21.3 cm./hr. (*Figure 3*). When the settling rates of 10 micron diameter particles of each of these two types of smokes are compared, it can be seen that the non-cellular particles will fall 1250 times faster than the cellular ones.

There is a great deal of information about all of the properties of foamed plastic particles which has not yet been obtained and at the present time our toxicological data on the effects of the smokes are virtually non-existent. However, it is believed that once the particles of these smokes are well dispersed in the air, the chances of their causing physiological damage are even less than those of particles of the conventional smokes. The nose filters out nearly all particles over five microns in diameter.

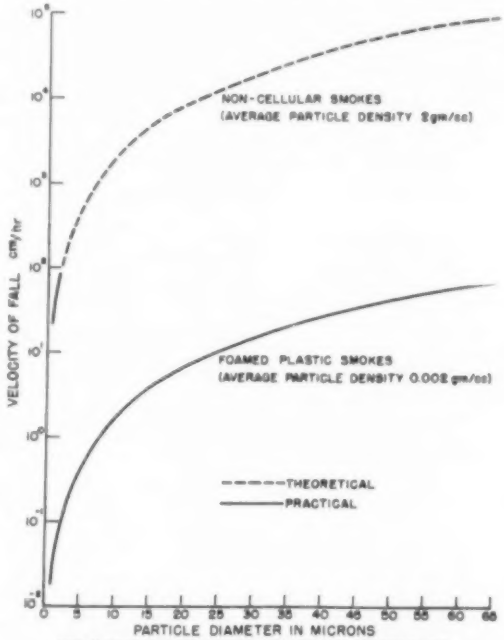
Figure 2. Microphotograph of 45 micron diameter phenolic particle showing spherical shape and detailed cellular structure (800-power magnification)

Potential Uses For Foamed Plastic Smokes

Since foamed plastic smokes are composed of low density particles with relatively large surface areas and since these smokes can be prepared on the job from comparatively small amounts of ingredients, they might prove useful for a number of diverse types of applications on land, sea, and in the air—literally from here to infinity. Virtually every one of the following potential uses for these smokes has either been suggested by or approved by a competent authority in the field pertaining to the particular application described. Only the sky projection use is proven.

- **Seeding of Rain Clouds**

  At the present time most cloud seeding experiments involve the ground liberation of a carbon smoke containing hexagonal crystals of silver iodide nuclei. It is difficult to get this relatively high density smoke above turbulent air areas, but the high cost of aircraft for dispersing these smokes makes ground operations necessary. Consequently, foamed plastic smokes might serve as economical, low density carrying agents, generated from


NON-CELLULAR SMOKES
(AVERAGE PARTICLE DENSITY 2gm/cc)
FOAMED PLASTIC SMOKES
(AVERAGE PARTICLE DENSITY 0.002 gm/cc)
THEORETICAL
PRACTICAL
VELOCITY OF FALL cm/hr
PARTICLE DIAMETER IN MICRONS
0 5 10 15 20 25 30 35 40 45 50 55 60 65

VELOCITY OF FALL OF SPHERICAL PARTICLES THROUGH STILL AIR AT 18°C

Figure 3. Velocity of fall of spherical particles through still air at 18°C

the ground, for cloud-seeding nuclei. The particles also might be useful as nuclei.

- **Crop-Warming Clouds**
  Since urethane foams have good thermal insulating properties and since smokes made from these foams have unusually slow settling rates in comparison with other types of smokes, perhaps these new smokes could be used for the protection of crops against low temperatures.

- **Prevention of Evaporation from Tanks and Reservoirs**
  Relatively large quantities of foamed plastic smokes could be dispersed over these containers in a relatively short period of time and the large surface area of the smoke particles should enhance the value of the smokes for this application.

- **Artificial Snow, Fogs and Smokes**
  Large particle size, foamed plastic smokes may be found very useful for simulating these conditions for scenes in television and motion picture work.

- **Carrier for Insecticides**
  Because of the unusually large surface area of the particles and the slow settling rates of the foamed plastic smokes, they might make efficient carriers for relatively large quantities of insecticides.

- **Reflection of Communication Radio Waves**
  If a cloud of metallized particles of a low density foamed plastic smoke could be strategically placed above the ionosphere, it might serve to improve the transmission of communication radio waves.

- **Smoke Screens, Smoke Signals**

- **Sky Writing and as a Screen for Sky Projection**

- **Outer Space Tracers for Rockets, Satellites**
  Metallized particles of foamed plastic smokes might provide a large mass of reflecting material which could follow a rocket or satellite and thereby make possible bigger echoing for radar tracking of these targets. Since it is believed that these particles will not simply float in space, but will be in some kind of orbit, smoke distortion patterns produced by rockets and satellites might also be found to have scientific value.

- **Shielding of Ground Personnel from Thermal Radiation Generated by a Nuclear Blast**

- **Decontamination—Polluting Gases and Solids from the Atmosphere**
  The extremely slow settling rates of foamed plastic smokes, the relatively large size of the particles in them, the electrostatic charge on the particles, and the fact that these particles can be literally "chemically tailored" from a wide variety of both absorbent and adsorbent types of foamed plastics makes them seem extremely promising for this application.

- **Fire-Fighting "Blanket"**
  Closed cell particles of a flame-retardant plastic filled with carbon dioxide or a fluorocarbon gas might be useful as a fire-fighting smoke, dispersed from an airplane.

Foamed Plastic Powders

Now consider foamed plastic particles in collected form as powders. These powders can be prepared by the foamed plastic smokemaking process using particle collection equipment in the path of the smoke. Foamed plastic particles have all of the properties previously mentioned in connection with the smokes. They can be readily colored or metallized; they can be prepared in either open or closed cell form (flexible or rigid consistencies) in a wide range of controlled particle sizes. Prepared from many different chemical types of resinous compositions, these spherical, cellular particles can take much more abuse than bulk foams of the same chemical type, cell structure, and density. Foamed plastic particles can be made to have relatively large surface areas and extremely low densities. For example, it was found that 13 gallons of about 100 micron diameter phenolic foam particles weighed only 520 grams. This is about the weight of one pint-size carton of milk. Although bulk phenolic foam of this same low density (0.01 gm./cc.) is extremely friable and cannot take much abuse, it was difficult to damage these particles.

Potential Uses For Foamed Plastic Powders

As with potential uses for foamed plastic smokes, the following list of potential applications for foamed plastic powders is based primarily on suggestions made by technical personnel in the fields related to the uses mentioned:

Light-weight Fillers for Plastics, Paper, Rubber Paints, and Concrete
Molecular-Sieve and Ion Exchange Resins
Flocculants
Textile and Paper Coating
Fluidized Beds
Filters—Laboratory, Industrial and Cigarette
Lubricants
Insulation—High Temperature and Low Temperature
Packing for Aircraft Wings, Tires, etc.
Nutrient Carrier for Soil
Cosmetics Filler and Pigment
Reflecting Surfaces for Movie Screens, Tapes, Clothing, etc.
Chromatographic Column Adsorbent

The costs of the basic ingredients for making foamed plastic smokes are higher on a pound for pound basis than those of the ingredients for most of the conventional smokes, except perhaps titanium tetrachloride. However, the most expensive foaming composition material used on this project cost 75 cents per lb., and this was a relatively high price because this composition was still in the developmental stage. Furthermore, it is believed that the money saved in using these particles for smokes and as powders may outweigh initial costs of ingredients or equipment.

Last year the Dow Chemical Company acquired from the author-inventor the exclusive world-wide rights to the commercial development of foamed plastic particles–for use as smokes and in collected form. Dow is currently engaged in research and development on this invention.

Acknowledgments

The author wishes to express her appreciation to the U. S. Air Force (WWRNGW of the Wright Air Development Division of the Air Research and Development Command) for having supported this research and to the U. S. Army Chemical Center and the U. S. Navy Bureau of Ships for having loaned some of the equipment used.

Epoxy Troweling Compounds — New Application Techniques

This article describes the design and construction of a machine which mixes epoxy resin, hardener and filler. The new machine can furnish mixed epoxy troweling compounds as fast as they can be applied

T. S. Loeser
Union Carbide Plastics Co.

The use of epoxy resins has branched-out into numerous industries previously unfamiliar with their use and in particular their application techniques. Problems have been encountered in proportioning, mixing and applying these resins efficiently. Too often the use of epoxy resins is handicapped by attempts at using this new material with old-fashioned tools.

This company's experience with the theory and practice of thermo-plastic extrusion and color-blending lead to the development of the "Epoxy Troweling Compound Mixer" which uses a conventional extrusion-screw to mix epoxy resin, hardener, and filler, such as sand, in a continuous operation.

Epoxy troweling compounds are a specialized type of epoxy coatings. An epoxy troweling compound is a highly filled, very viscous epoxy based formulation that is quite similar in consistency to cement or plaster. As is implied by their name, these compounds are applied to a surface with the aid of a mason's trowel. Typical applications are: resurfacing and patching concrete floors, protective coatings for the inside of tanks and silos, non-skid surfaces for loading docks and ramps, and patching and resurfacing of concrete highways and bridges.

The successful use of epoxy troweling compounds can only be achieved upon the consideration of several important factors.

1. Selection and incorporation of fillers.
2. Proper metering of ingredients.
3. Utilization of efficient application equipment.

Selection and Incorporation of Fillers

Epoxy troweling compounds contain a great amount of fillers, pigments, and various other extenders and solid additives. Sometimes, as much as 300 to 400 per cent filler, based on the total weight of resin and hardener, is used.

A typical epoxy troweling compound formulation is shown in *Table 1*.

This troweling compound is conventionally prepared by blending the epoxy resin with the solvent using a propeller type mixer or similar device. The "Cab-O-Sil" is then added and mixed in, followed by the various ingredients one at a time, which comprise the resin portion of the compound. The sand is the last ingredient to be added. The blend is then allowed to mix for an additional length of time in order to obtain a thorough dispersion of all the ingredients.

This typical troweling compound would be packaged in two containers—the resin portion in a five-gallon pail and the proper amount of hardener packaged in a separate one-gallon can. When the troweling compound is to be used, on the job site, the resin and hardener cans are opened; the hardener poured into the resin can; and mixed, either by hand or with a power mixer. Another mixing method would be to first charge the resin portion into a trough (same type as used for mixing cement). The hardener is then poured over the resin portion and mixed with a hoe just as a mason's helper would mix cement. By using premeasured amounts of resin and hardener, inaccurate proportioning of resin and

Table 1.—Typical Epoxy Troweling Compound

Material	Quantity
RESIN PORTION	
BAKELITE Epoxy Resin ERL-2774	100 pts.
CELLOSOLVE Solvent	10 pts.
Titanium Dioxide R-610 (RUTILE)	15 pts.
"Barytes" No. 1 Barium Sulfate	30 pts.
"Asbestine" 3X Magnesium Silicate	80 pts.
"Cab-O-Sil" Colloidal Silica	3 pts.
Sand AGS Co. No. 3, 40 Mesh	150 pts.
Resin Total	388 pts.
HARDENER PORTION	
BAKELITE Epoxy Hardener ZZL-0814	25 pts.
Mix Total	413 pts.

hardener on the job site is averted. Mixing of the troweling compounds by hand is difficult due to the very viscous nature of the mix. Although the use of a power mixer overcomes this problem it encounters difficulties in equipment clean-up. Portions of the compound can cure on the mixing equipment. Both methods are hampered by pot-life limitations of the mix in the trough.

Proper Metering of Ingredients

Generally speaking, epoxy troweling compounds, of the two-part type, as described above, have been known for some time but have never reached wide-spread use due to two major reasons: (1) crude handling methods, and (2) high costs of compounding a highly filled epoxy troweling compound. It was therefore, with the aim of integrating epoxy resins into a workable production technique using suitable equipment that the Development Department of Union Carbide Plastics Company, embarked on the program of developing epoxy handling equipment. The prime purpose was to develop labor-saving devices so that the cost of using epoxies would not be prohibitive. This is in direct line with the viewpoint expressed in Harvard Business School Survey on Epoxy Resins, prepared in 1959, which stated that *the limiting factor in the acceptance of epoxies was not the price of the resin itself, but the costs encountered in using them.*

A workable epoxy troweling compound mixer has been developed. It is a machine capable of continuously furnishing mixed epoxy troweling compounds at a rate equal to the rate at which they can be applied.

The epoxy troweling compound mixer (*Figure 1*) consists of a resin and hardener metering system, a filler metering system and a vertical mixer-extruder. The resin and hardener components are metered and proportioned using two positive displacement gear-type pumps; such as "Zenith", "Viking", or "Gerotor" pumps. The resin and hardener are gravity fed to the pumps, which are driven through an adjustable speed "V" belt drive by a 1/3 HP electric motor. The pumps force the two streams to the mixer-extruder, where they are simply poured in continuously. As for the fillers, they are metered to the mixer-extruder using a "Syntron" vibrator, and are gravity fed from the filler hopper. The metered stream of filler is also allowed to fall directly into the top of the mixer. The mixer-extruder consists of a vertically mounted extruder screw rotating (50-200 rpm) in a barrel, driven by a ½ HP electric motor, with a funnel-shaped feed section. The three components, resin, hardener, and filler, are fed into the top of the mixer, at their proper individual rates to yield the desired formulation. The rotating screw mixes and extrudes the troweling compound ready to be used.

The resin and hardener flow rates in this apparatus are adjustable due to the incorporation of the variable speed drive. The filler flow rate can be adjusted by the "Syntron" vibrator. The mixer screw speed is also adjustable through a variable speed drive. The latter adjustment permits the troweling compound mixer to handle a wide range of formulations at rates from 100 to 1000 pounds per hour.

The mixer-extruder is the heart of the whole operation. Its design is based upon this company's knowledge of thermolplastics extrusion and color blending. The screw and barrel have been designed (*Figure 2*) with utmost simplicity. The screw, made of machined cast iron, has a very high compression ratio in order to provide a high rate of back flow and, consequently, a high rate of shear occurs around the flights of the screw, thereby insuring adequate mixing. The barrel of the mixer is a piece of 3-inch pipe, while the funnel-feed section is made of cast aluminum. The barrel fits into the funnel section as an insert and is held in place by setscrews. The only parts subject to wear are the barrel and screws. Both can be replaced easily and inexpensively. Cleaning of the parts is a very simple operation. The resin and hardener pumps are shut off. Sand is circulated through the screw to thoroughly scour it out. A substitute method of cleaning would be to disassemble the screw and barrel section and soak the parts in epoxy-strip (solvent).

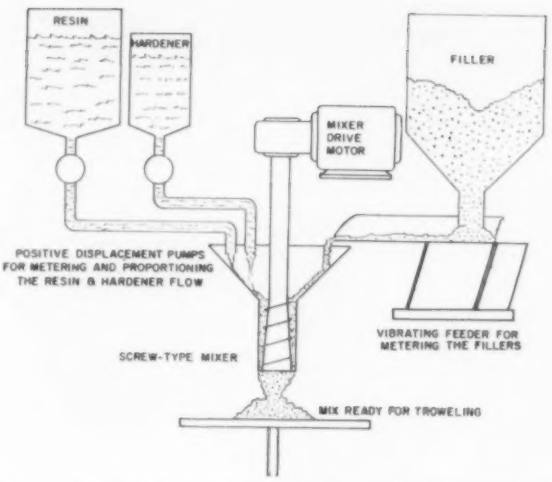


Figure 1. Drawing of epoxy troweling compound mixer. New machine uses a conventional extrusion-screw to mix epoxy resin, hardener, and filler, in a continuous operation

The clearance between the mixing screw and the inside wall of the mixing chamber is determined by the filler particle size and mobility. The mixing chamber shown in *Figure 2* has a clearance of approximately 3/16". It has been successfully used to mix troweling compounds containing sand ranging from 100 mesh to 12 mesh. "Micro-Balloon" phenolic spheres of a mesh size less than 200 have also been mixed to make a cellular mortar (syntactic foam) of approximately 30 lb/cu. ft. density. Highway patches for a bridge on the

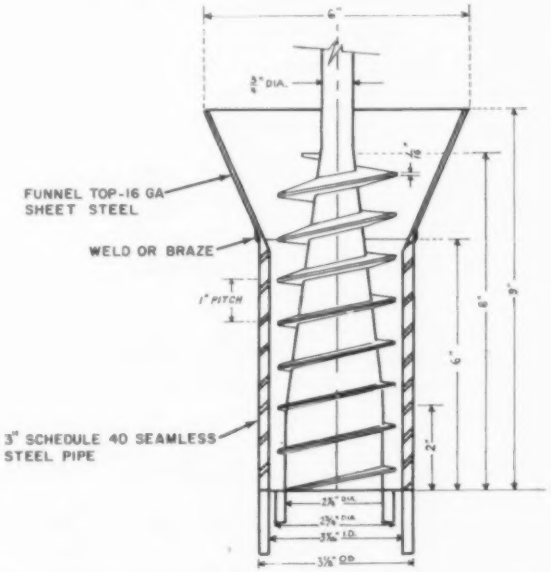


Figure 2. Screw and barrel details. Only parts subject to wear are the barrel and screws—both easily replaced

Figure 3. Front-side view of commercial model of epoxy mixing machine

New Jersey Turnpike were easily mixed using washed pebbles of approximately 1/8" to 3/16" diameter. An epoxy terrazzo flooring compound was mixed using a filler mixture of size 1 and 2 marble chips. There is no basic reason why large aggregate could not be conveniently used by the troweling mixer providing that the mixing screw is designed to handle it without jamming. A good rule of thumb to follow in screw design is to make the screw clearance plus the channel depth of the screw approximately 2-1/5 times the diameter of the largest aggregate to be used. This prevents the toggling of one aggregate particle over another which can impose tremendous forces jamming the screw in the barrel as it rotates.

The G. Diehl Mateer Co. of Wayne, Pennsylvania, is now producing a commercial model of this machine. The machine is shown in *Figure 3* and is completely self-contained, with tanks for resin, hardener and filler. It is designed to operate on either 110 or 220 volts AC, providing a maximum rate of 1000 pounds per hour. In addition, it can be conveniently operated using a portable generator when electric power is not available.

Three typical epoxy troweling compound applications comparing hand mixing versus machine mixing are listed in *Table 2* which show labor savings achieved.

The troweling compound mixer allows labor savings up to approximately 50 per cent plus the additional advantage of eliminating the pot life problem commonly associated with epoxies. This difficulty is not encountered since the material is being mixed only as fast as it can be applied by the workers.

Use of the troweling compound mixer offers, in addition to handling convenience (the elimination of pot-life problems), the benefit of quick mixing. Resin, hardener, and

Table 2. Hand Mixing Compared With Machine Mixing—Savings are Significant

Area sq. ft.	Application Method	Filler, % on resin and hardener weight	Labor Man Hr. / Sq. Ft.
14.4	Hand mix hand trowel	500	0.087
28.8	Machine mix 385 lb./hr. hand trowel	900	0.044
28.8	Machine mix 210 lb./hr. hand trowel	450	0.0625

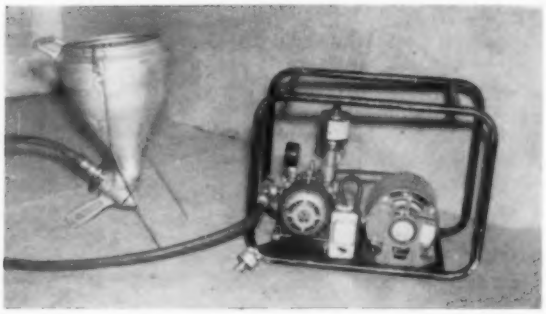


Figure 4. Commercial model of spray unit designed to handle highly filled epoxy troweling formulations. The spray unit is natural complement to the troweling compound mixer

fillers come together, are mixed, and the mix extruded ready to be used in a matter of seconds. The speed of mixing, however, raised some doubt as to the adequacy of the mix provided by the mixer. In order to verify the mixing quality of the machine, identical troweling compounds were formulated. One group was hand mixed and the other group was machine mixed, and allowed to cure. The samples were immersed in solvents, such as CELLOSOLVE, Acetone, and MEK, and the weight gain plotted against days immersed. Machine mixed formulations exhibited superior solvent resistance—showing that the machine mix provides a better, more chemically resistant compound that is uniformly and completely mixed with no human error entering in.

The epoxy troweling compound mixer not only insures a continuous supply of better mixed material but also excludes mixing by hand, cutting labor costs approximately in half. These ideal properties should allow for more extensive use of epoxies where cost was previously a barrier.

Utilization of Efficient Application Equipment

A novel method of applying epoxy troweling compounds is through the use of the "Quik Spray Unit", made by Quik Spray, Inc., Port Clinton, Ohio. The "Quik Spray Unit" consists of an air compressor (10 to 20 psi-20cfm) and air hose, and a spray gun with a 1½ gallon gravity or pressure-fed hopper (*Figure 4*). The spray gun is designed to handle the highly filled epoxy troweling type formulation. The mixed material is placed in the hopper of the spray gun where either gravity or air pressure forces the material to the spray orifice. An air jet, mounted behind the spray nozzle, blasts the highly filled epoxy formulation out into a spray pattern on the surface being coated.

The "Quik Spray Unit" is a natural complement to the troweling compound mixer because of its ability to spray highly filled epoxy-based materials at high rates, thereby eliminating the need for troweling. Vertical surfaces, generally a difficult job to cover by troweling, can be covered by spraying, and require only rolling with a paint roller to produce a good finish. By spraying a properly formulated coating on a floor, even rolling can be eliminated by the self-leveling action of the mix.

The epoxy troweling compound mixer and the "Quik Spray Unit" comprise a very effective team for use in applying epoxy troweling compounds. The mixer can be adjusted to furnish a mix at a rate equal to the spray unit's consumption. The pot life problem is minimized, and labor costs are reduced. These properties add up to the successful and efficient application of epoxy troweling compounds.

Adapted from a paper presented to the 17th Annual Technical Conference in Washington D. C., Jan. 24-27, 1961.

New Heat Resistant Phenolic Molding Materials

- *New applications such as missiles and aircraft*
- *Old applications which are being redesigned*
- *Replacement of ceramic and metal parts for economic reasons or other advantages such as light weight*

W. G. Colclough, J. Harding, and C. Y. Meyers
Union Carbide Plastics Co.

In the past few years there has been increasing need for thermosetting plastics which will tolerate higher operating temperatures and longer periods of heat exposure than the presently available phenolic and epoxy materials.

To meet these needs a new phenolic molding material has been developed with significantly better heat resistance. It is estimated that the new material can be used at operating temperatures 75°F higher than are used for commercially available asbestos-filled phenolic compounds. Expressed another way, the new material will last four times longer at 500°F.

This material is based on new phenolic resins which also offer promise in improving the heat resistance of high impact molding materials and other applications such as laminates.

High Temperature Tests

The thermal stability of phenolic molding materials is often determined by measuring the weight loss after various periods of heat ageing. By this test, the best commercially available phenolics—even though they had been post-cured—lost 20% of their weight after aging 325 hours at 500°F. The new material—which had not been post-cured—lasted 750 hours before losing the same amount of weight. The comparison is shown in *Figure 1*.

Another more practical test is the retention of strength when aged under the same conditions. *Figure 2* shows this data. Present phenolic molding materials, which had been post-cured, degraded in flexural strength from 9000 psi to less than 2000 psi in 150 hours at 500°F. The new material, which did not require post-curing at this temperature, lasted over 700 hours at 500°F before its strength was degraded as much. The strength of the new material was essentially unchanged after 400 hours at 500°F. The solid lines in *Figure 2* show the strength values that were determined after the specimens were cooled to room temperature. The dotted line shows the strength measured at 500°F and demonstrates that although the values are slightly lower, the strength retention follows the same pattern as when measured at room temperature.

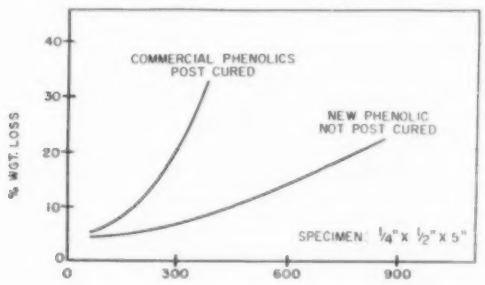


Figure 1. New heat resistant phenolic molding material ageing at 500°F

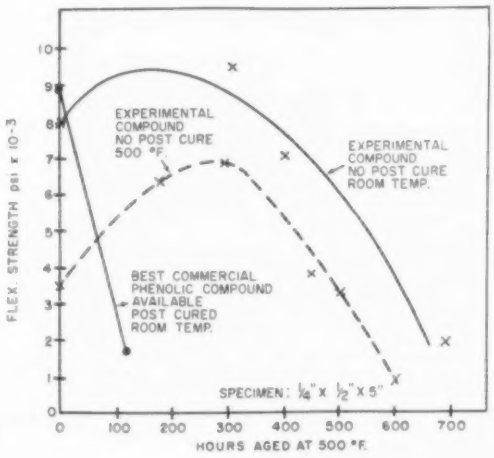


Figure 2. Retention of strength after ageing at 500°F

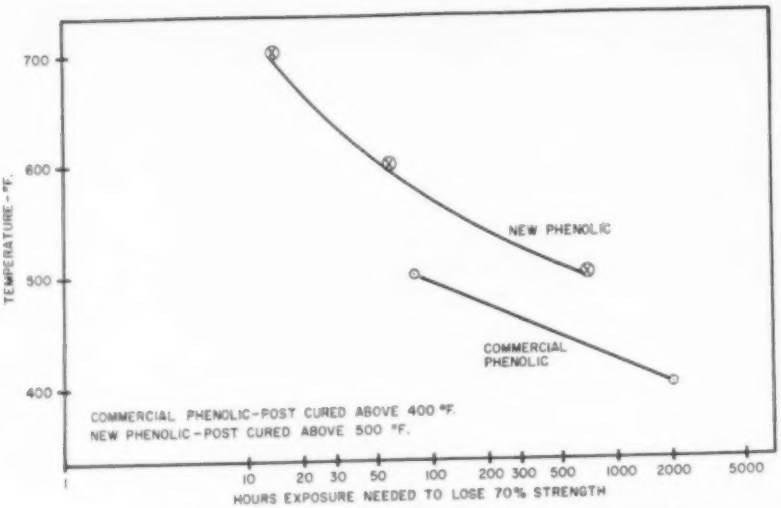


Figure 3. Commercial phenolic-post cured above 400°F. New phenolic-post cured above 500°F

Ageing at 600°F and 700°F is much more severe than at lower temperatures. *Figure 3* shows the relative effects of exposure time and temperature on strength retention. The continuous service life of the new material at 600°F is only one-tenth of what it is at 500°F. At 700°F it is only one-fiftieth of what it is at 500°F. By extrapolation, the new material should last ten to twenty times longer at 400°F, and tests are being conducted to confirm this.

Post-curing is employed in order to obtain the maximum initial high temperature strength for molded parts that are to be subjected to very high temperatures. Post-curing helps to eliminate blistering and cracking, thereby producing greater initial high temperature strength. *Figure 4* illustrates that the flexural strength at 500°F has been increased 100% by post-curing in the following manner: Maintain a temperature of 270°F for 16 hours. Then, over an eight hour period, slowly raise the temperature to 500°F and maintain it for 16 hours. Cool slowly.

It should be noted, however, that with this new material, post-curing is not necessary unless the parts are to be exposed to temperatures above 500°F.

Post-curing and heat ageing also influences the electrical insulating properties of phenolic materials. These properties for the new material are basically similar to those of other asbestos-filled phenolics except that the arc-resistance is superior. In the ASTM arc-resistance test, the new material had an average value of 195 seconds whereas typical heat resistant phenolic molding materials have values lower than 180 seconds. By post-curing the new material in the same cycle that was used to maximize strength at 500°F, the arc-resistance values were raised to an average of 240 seconds with no individual value lower than 200 seconds.

Heat ageing for 100 hours at 600°F or 400 hours at 500°F degraded the electrical properties when they were measured at room temperature. This appeared to be caused by moisture pickup when the material cooled down to room temperature. The properties were still good when measured at a temperature of 100°C where the moisture would have been driven off.

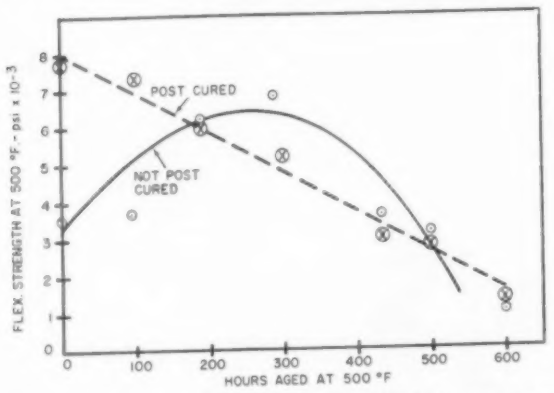


Figure 4. Effect of post curing on high temperature strength

Processing

The new material can be molded in the same presses and molds that are used for commercial phenolic molding materials and does not require any special molding techniques. It has been compression molded at mold temperatures from 300°F to 365°F using molding pressures from 2000 to 4000 psi. At temperatures of 335°F or above the new material is as fast in cure as standard heat resistant materials (based on minimum cycle times needed to mold a blister-free cap with a ¼ inch thick section).

The new heat resistant material can also be transfer or plunger molded. It can be preheated electronically and is available in a free flowing powder which can be fed automatically.

Typical properties of the material other than heat resistance are shown in *Table 1*. Uses for the new material: appliance parts, pot handles, electrical switch gear, industrial and missile parts. In addition, there is the possibility of replacing some ceramic and metal parts. For example, some sections of the metal shell of a toaster were replaced with molded pieces of the new material to determine if the material would withstand the heat conditions. The toaster was then put through a life test of 12,000 cycles. The molded parts held up under the test even at the top of the toaster where the inside surface was as hot as 482°F. Of interest is the fact that the outer surface of some of the plastic pieces ran 70°F cooler than the metal shell. This would make the toaster easier and safer to handle.

Field trials of this new heat resistant phenolic molding material are now underway. Though existing phenolic materials will be replaced in some cases, it is anticipated that the new material will make possible applications formerly beyond the reach of existing plastic materials.

■

Table 1. Typical Properties of New Heat Resistant Phenolic

Properties	Value
Specific Gravity	1.9
Izod Impact Strength-ft. lbs./in. of notch	0.27
Heat Distortion Temp.	over 500°F
Mod. of Elasticity in Flexure—psi	24×10^5
ASTM Water Absorption—% Wt. Gain	0.22

Casting to Close Tolerances with Unfilled Epoxy Resins

- *Epoxy castings can be made with dimensional tolerances of ± .001 inches in two directions in open molds*
- *Essentially no movement of embedded parts takes place in low exotherm, open mold castings*
- *Epoxy resins can be specially formulated without fillers to reduce internal stresses and to improve shock resistance of castings*

B. W. Nelson, E. J. Morrisey and S. D. Marcey

The National Cash Register Company, Plastics Laboratory

The mechanical parts in business machines such as operating keys and motor brush holders are traditionally made by injection and compression molding. With the advent of electronic techniques for business machine operation, the plastics engineer is faced with the problem of producing delicate electrical components of close dimensional tolerances insulated with resinous materials. It was obvious that these electrical components could not be inserted into injection or compression molds and subjected to the cavity pressures associated with these techniques. The casting process offers a ready solution to the problem.

Casting of sheets and embedment of delicate objects are well-established production processes. Similar handling of polyester resins has been developed. In recent years, the art of casting epoxy resins has advanced at an ever increasing rate. The introduction of new curing agents and modifiers has kept this development in a state of flux.

This article describes the casting of epoxy resins for embedding delicate electrical and electronic machine components. In casting any epoxy system, a change in volume results which can be attributed to its change of state, that is, from liquid to solid, when temperature of the mass remains constant. This phenomenon is referred to as volumetric shrinkage. Using a special test apparatus, Lascoe (1) found a volumetric shrinkage for an unfilled epoxy-diethylene triamine composition to be 3-5%. Such a shrinkage is inevitable and must be considered in mold design.

In addition to the volumetric shrinkage attributed to the change of state, there is a second change in volume which can take place from exothermic reaction. When casting a resin mass in which a significant temperature increase or exotherm takes place, the expansion of the liquid during temperature rise, the conversion of the liquid to a solid at this higher temperature and the contraction of the solid during temperature decrease, contribute to this second change in volume. This phenomenon is referred to as exothermic shrinkage.

A given epoxy system, cured in a paper cup or thin metal container at ambient temperatures, exhibited both of these shrinkages. It was observed that castings of the same system made in heavy steel molds at ambient temperatures did not shrink away from the sides of the mold. It was concluded that the steel molds were acting as a heat sink for the resin system immediately adjacent to the mold.

The epoxy resin adjacent to the mold was the last to solidify or cure. Its exotherm was very small. This area of resin experienced a volumetric shrinkage only. Elimination of exothermic shrinkage and the excellent wetting characteristics of the epoxy resin accounted for an extremely accurate reproduction of the mold cavity.

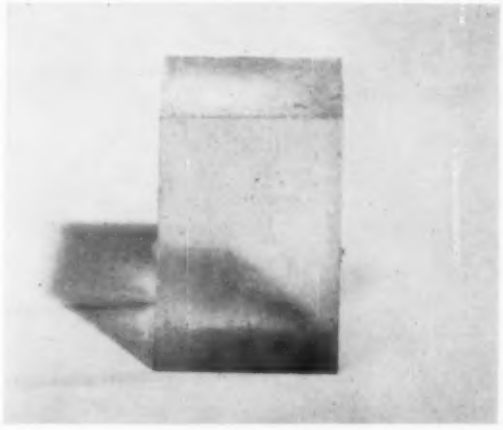


Figure 1. Low exotherm epoxy casting. Ideally, such casting should show no exotherm when a thermocouple is embedded in the center—in practice it does

Experimental Castings

A low exotherm casting is shown in *Figure 1* and is characterized by uniform color, bubble-free appearance and accurate reproduction from the mold.

Ideally, such a casting should show no exotherm when a thermocouple is embedded in the center. In actual practice, a temperature rise up to 200°F can be tolerated in the center and a very small exotherm will be present adjacent to the steel molds.

An epoxy resin system with an excessive exotherm, approximately 350°F, characterized by the dark center portion, *Figure 2*, did not produce a casting representative of the mold cavity. Poor mold fill-out was evidenced in the corners.

Another epoxy system with an excessive exotherm and containing a high vapor pressure ingredient exhibited a pronounced bubbled appearance. Also, poor mold fill-out occurred in the corners.

The ability to cure epoxy resins in a reasonable lapse of time and achieve little or no shrinkage from the sides of a steel mold has made epoxy resins of the utmost significance to the National Cash Register Company. The application of this principle to tooling has been published elsewhere (2, 3).

Critical Castings

The center of an experimental mechanical part shown in *Figure 3* was cast in one operation around 160 lapped and polished steel pins. The height was overcast and, after removal of the part from the mold, it was machined to $\frac{5}{8}$ inch thickness. The cast center section was 1 inch wide and 6 inches long. A tolerance of plus or minus .001 inches was held between the centers of the holes from end to end.

Figure 2. High exotherm epoxy casting—note poor mold fill-out in the corners

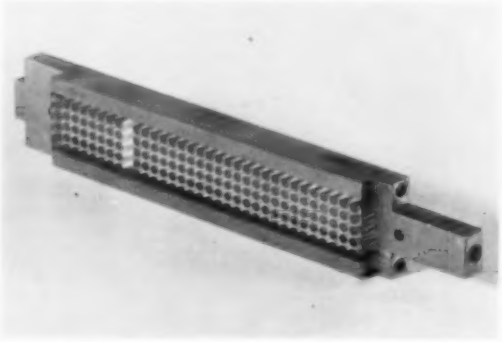


Figure 3. Plunger guide, steel side frame and cast epoxy-guide hole section

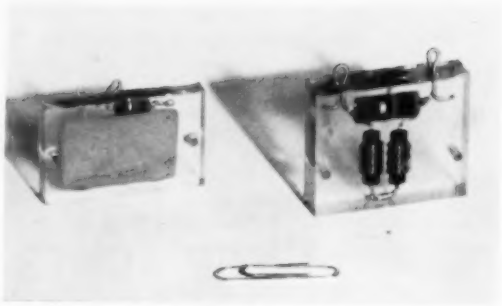


Figure 4. Spark suppressor circuits

The two spark suppressor circuits shown in *Figure 4* are embedded to retain circuit integrity and to facilitate mounting in a business machine. The mounting holes are cast in place with a tolerance of plus or minus .003 inch between centers.

The latter application did not involve accurate location of the embedded electrical components in the final castings. Just how much delicate components would be subject to movement during the curing process due to volumetric shrinkage was of concern.

Experimental Embedments

The following experiments were conducted to determine the extent of any such movement: A thin metal plate similar to that shown in *Figure 5* with five .008 inch diameter soft iron wires protruding perpendicularly from the middle was placed in the mold shown in *Figure 6*. The mold cavity is .150 by .263 inches in cross section and 6 inches in height. Liquid resin was poured down the 6 inch height and cured at room temperature. No exotherm occurred during the curing cycle.

The purpose of this experiment was to measure any movement of the soft wires during embedment. By means of a Contour Projector Gage, an average center line was assigned along the length of two wires and the distance between the center lines was measured before embedment. After embedment, center lines were re-assigned to the wires and the distances between them measured. While a downward shrinkage was observed at the open end of the 6 inch height, shown in close-up in *Figure 7*, the center line movement was, at most, .0002 inches.

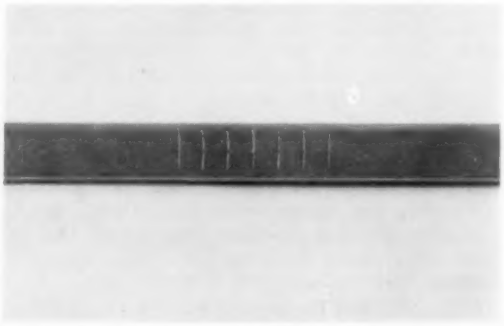


Figure 5. Center section of 20" plate with seven soft wires protruding perpendicularly

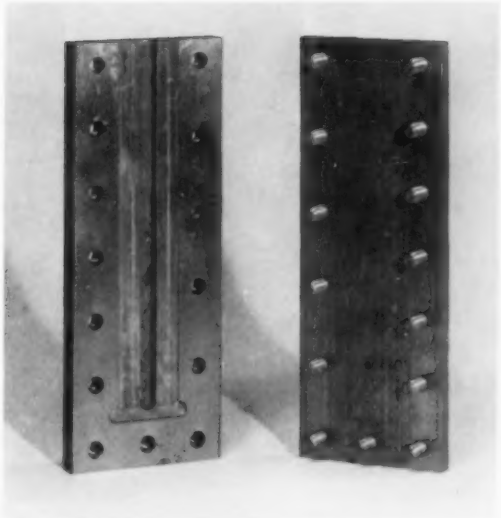


Figure 6. Mold for embedding soft wires attached to 6″ plate

This experiment was repeated with three sets of seven soft wires individually located near the bottom, in the middle and near the top of a 20″ length plate. The center section of the plate is shown in *Figure* 5. Similar slight movement of the center lines was observed.

This phenomenon of essentially no movement of embedded parts during a minimum exotherm cure allowed further applications of embedding electrical components in epoxy resin.

Critical and Delicate Embedments

A miniaturization application, shown in *Figure 8*, is the first example of this type of embedment. In the original design, the wiper arm was secured to the metal support

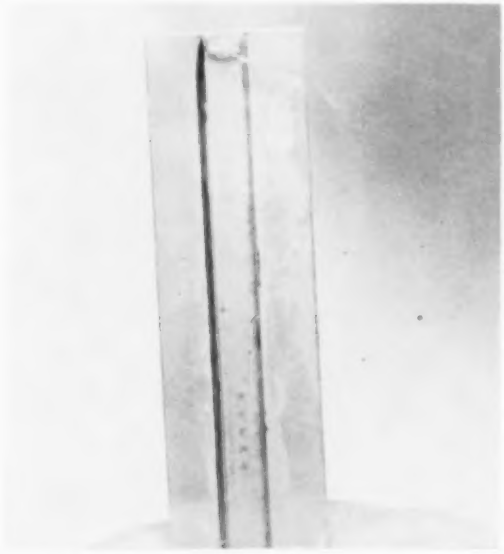


Figure 7. Close-up of end of 6 inch casting showing volumetric shrinkage

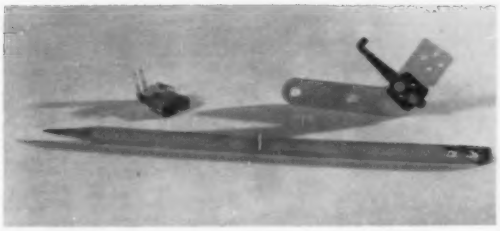


Figure 8. Miniaturization of an electro-mechanical wiper blade

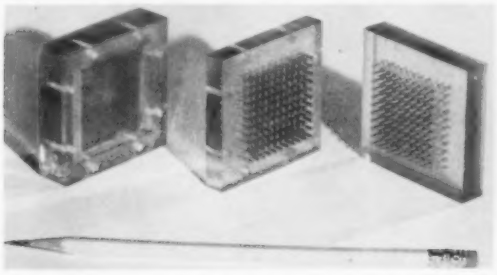


Figure 9. Experimental device cast in silicone rubber mold

with insulating rivets (on the right in *Figure 8*). In the embedded design, support and insulation were adequately provided in a much smaller space (on the left in *Figure 8*). Length and width tolerances of plus or minus .005 inches were held and an identical tolerance was held on the position of the blades from one end.

A special formulation was used to cast a magnetic sensing head. A thermal and mechanical shock-resistant compound was designed for protection of the unit. No change in electrical characteristics of the embedded part could be tolerated due to stresses introduced by volumetric shrinkage of the epoxy resin. Two different compositions were formulated which performed satisfactorily; the one, containing a polysulfide polymer and an aliphatic polyamine curing agent, and the other, a room temperature curing agent-flexibilizer amine adduct. Actually, in production, an oven temperature of 150°F is used to cure the resin to allow an economical operational cycle.

An experimental device consisting of three parts, as shown in *Figure* 9, is an application in which a silicone rubber mold was used. The primary concern here was a perfect fit of the mating sections, right and center. The exotherm was controlled by using a compound of special formulation.

Steel masters were made with identical pin locations. Silicone rubber molds were cast using identical compositions, cure times and temperature. The epoxy casting procedure was handled with the same attention to uniformity. As a result, the mating sections fit very well, and in addition, they also fit when one is rotated 90 degrees.

Literature References

1. "Shrinkage Test Method", O. D. Lascoe, *ASTE Research Report No. 6*, August 10, 1957.
2. "Epoxy Shedders", T. W. Black, *Tool Engineer*, Page 89, March, 1958.
3. "Some Practical Applications of Cast Plastics for Tooling", B. W. Nelson and E. J. Iorrisey, *ASTME Technical Paper No. SP-6023*.

Evaluation of High Impact Polystyrene for Refrigerator Door Liners

One Company's approach to materials qualification testing for appliance service

D. A. Davis, J. V. Schmitz, R. S. Hagan, R. O. Carhart
General Electric Company

The use of high impact polystyrene, thermoformed into refrigerator door liners, has been widely accepted during the past five years. There remains, however, a difference of opinion on what properties or tests are required for a satisfactory extrusion grade material for this application (1). Six years ago, the plastics industry offered only a limited number of high impact polystyrenes that could be used in the manufacture of inner doors. Numerous formulations are available today. These modern materials are considerably superior to the few materials available in the beginning stages of this plastics application.

Three years ago, our company undertook a program of evaluating the various impact styrene materials which, by trade literature, were similar in properties and processability. We have expended considerable effort since then in developing test methods to define our requirements.

Sample Requirements

Until recent years, except for one major chemical company, the suppliers of high impact polystyrene have furnished property data only on injection molded samples. It is well known that the properties of high impact polystyrene samples prepared by compression molding, extrusion, and injection molding will differ considerably.

Ideally, evaluation of high impact polystyrene for refrigerator door applications should be made on formed parts. This is done in G.E.'s simulated service tests. Other property tests are run on extruded sheet. In this way, all of the materials tested will have been subjected to a similar thermal history. The extruder and sheet former, however, must be carefully monitored in order to secure samples that are satisfactory for test purposes.

Four simple tests are run on all sheet samples prior to physical property testing. They are orientation shrinkage, color match (if required), thickness tolerance and appearance. The single most important test of the four is orientation shrinkage. Many extruders of high impact polystyrene produce sheet material which is far from isotropic. In fact, until three years ago, our own seven lines of captive sheet extrusion consistently produced sheet which was anisotropic.

The extrusion of sheet plastics will generally produce some degree of orientation. The hot extrudate is fed from a die around an S wrap of three steel cooling rolls, or onto a conveyor, where the heat is removed. The sheet is pulled through a pair of rubber rolls and then fed into a shear after the material has cooled to a rigid form. Improper die lip settings or mismatch in speeds within the take-away equipment or extruder will generally cause the sheet to be stretched. Nielsen and Buchdahl (3) explain the stretching process as causing the polymer molecules to become arranged in an abnormal configuration. On cooling, this configuration is "frozen in", leaving the molecules in an oriented state. It has been reported by a number of authors (3), (4), (5)

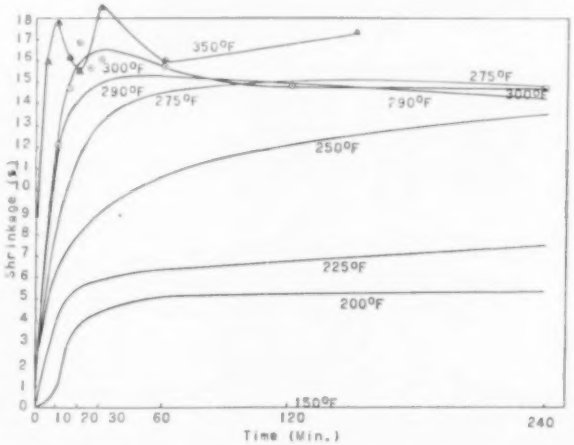


Figure 1. Orientation shrinkage vs time curves show best equilibrium shrinkage test is 30 min. @ 290°F

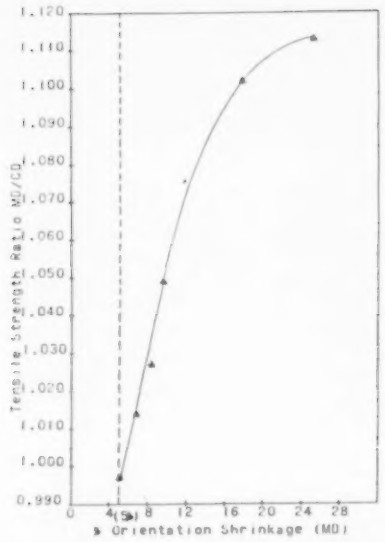


Figure 2. Ratio of machine direction and cross machine direction tensile strengths shows little anisotropy below 5% orientation shrinkage

that material which has been oriented in one direction will result in anisotropy.

Prior work on sheet properties had disclosed that we had a consistent unbalance in sheet properties such as tensile strength and Izod impact strength (notched). Higher values were observed in the axis of extrusion or machine direction (MD) than perpendicular to the axis of extrusion or cross machine direction (CD).

Orientation Shrinkage Test

To establish a good evaluation procedure for sheet, the first step was to devise a test for orientation shrinkage. Birefringence is the normal method of measuring orientation in transparent polymers. High impact polystyrene is an opaque material which precludes the use of such optical measurements. Therefore, a simple shrinkage test was devised as a practical approach to measure the degree of orientation.

For test purposes a large quantity of sheet was collected from a production extruder. Test specimens were taken from a six inch wide strip out of the center of the sheet. The premise was made that the orientation would be constant along the entire length of this six inch wide strip. This was subsequently verified within a practical tolerance of ±1%. The test consisted of heating the sheet and measuring the shrinkage. Specimens were 6 x 6 inch squares. Five inch diameter circles were drawn on each sample and accurately measured to the nearest 0.010" in the axis of extrusion. Each sample was placed on a sheet of aluminum which had been coated with talc for freedom of movement. A set of three samples per condition was placed in an air circulating oven for a specific time and temperature. The samples were removed, allowed to cool to ambient temperature, and rechecked for diameter dimension. Additional sets of samples were tested by varying time and oven temperature. The change in dimension divided by the original dimension times 100 was reported as % shrinkage in machine direction (axis of extrusion).

From this experiment, we secured a family of curves by plotting % shrinkage versus time. This is shown in *Figure 1*. The optimum time and temperature chosen from these data were 30 minutes and 290°F. Temperatures above 300°F were discarded for consideration since the polymer showed evidence of degradation. Temperatures below 290°F, such as 275°F, were not used since the time interval to reach equilibrium shrinkage was considered too long. The temperature chosen is in agreement with the work of Cheatham and Dietz on polystyrene (2). This test was further verified by rerunning a sample through the test more than one time. No practical measure of change could be detected after the first test at 290°F for 30 minutes.

Table 1. Specification Values for High Impact Polystyrene

Physical Properties	
Tensile Strength (crosshead speed of 0.2 ipm), psi	3000 Min.
Elongation at Rupture (crosshead speed of 0.2 ipm), %	25 Min.
Flexural Strength at Maximum Load (crosshead speed of 0.05 ipm), psi	6500 Min.
Modulus of Elasticity in Flexure, psi	3.0×10^5 Min.
Izod Impact Strength at 73°F, ft-lbs/in. of notch	0.8 Min.
at 0°F, ft-lbs/in. of notch	0.4 Min.
Falling Dart Impact Strength, 45" drop on either side of sheet, ft-lbs.	30 Min.
Creep Yield Time under 2000 psi initial stress, minutes	150 Min.
Creep Rupture Time under 2000 psi initial stress, minutes	10,000 Min.
Axial Fatigue (tension-compression), 20,000 cycles, psi	2000 Min.
500,000 cycles, psi	1000 Min.
Hardness, Rockwell R Scale	100 Min.
Deflection Temperature under 264 psi load, °F	168 Min.
Thermal Stress Induced in Cooling from 110°F to −20°F, psi	1900 Max.
Chemical Properties	
Flammability, ipm	2.5 Max.
Toxicity	Non-toxic
Water Absorption, 24 hr. immersion, %	0.15 Max.
Total Volatile Content, %	0.5 Max.
Styrene Monomer Content, %	0.3 Max.
Odor—must be free from objectionable odor and shall not impart objectionable taste to butter or water.	
Color—must be an acceptable match to the appropriate color standard.	
Simulated Service Properties	
Door Slam, cycles without failure	500,000 Min.
Cyclic Door Racking, cycles without failure	10,000 Min.

NOTE

The above values are as measured on specimens cut from extruded sheet having a thickness of $0.115 \left({}^{+0.005"}_{-0.000"} \right)$ and an orientation shrinkage of less than 5%. Test specimens are cut in cross machine direction. Tests are run at 73°F, 50% R.H., unless otherwise specified.

A monitoring program was then initiated on our seven lines of sheet extrusion to determine the practical effects of orientation as measured by shrinkage. Sheet samples were collected twice per shift per machine per day for a period of one week. Orientation shrinkage was determined and a number of physical property tests were run in both MD and CD. Two major effects of extrusion conditions on sheet orientation were discovered. First the overall value of orientation shrinkage for this series of samples varied from 1% to as high as 30%. In addition, frequently the shrinkage was not constant across the width of the sheet and varied as much as three-fold. A compilation of over 400 tensile strength and Izod impact values for this series indicated a trend. Anisotropy was highest in the samples which had the highest orientation shrinkage. *Figure 2* is a plot of all the data secured on tensile strength and orientation. Tensile strength is plotted as a ratio of machine direction values to cross machine direction values. Sheet which has an orientation shrinkage by this test above 5% gives a measurable degree of tensile anisotropy depending on the orientation secured. The higher the shrinkage value, the greater the unbalance in physical properties of the sheet. Similar effects were found on Izod impact tests. These results are reported in a 17th ANTEC paper (6). It is noted from the data presented in *Figure 2* that a balance in physical properties exists at about 5% shrinkage. This maximum value was therefore chosen as our standard for extruded sheet.

Specifications

A large segment of the end users of high impact polystyrene base their material choice more upon appearance, processability, and technical service than the physical properties of sheet. This has come about since most chemical companies release sales literature on a minimum number of physical properties. A comparison of sales literature on properties would lead the end user into believing that most high impact polystyrene materials are essentially equivalent. During the past three years we have evaluated practically every important high impact polystyrene material offered to the market plus numerous research materials. Many of these materials differ widely in the physical properties required for refrigerator inner doors. The areas of greatest difference today in high impact polystyrene polymers are impact (6) and time-dependent properties (7). These are not reported in sufficient detail in sales literature. It is encouraging to note that major suppliers are now doing considerable work in this area. However, far too much knowledge of the engineering properties of commercial materials has been held confidential within the chemical companies. It is virtually impossible for a mechanical engineer to design structural plastic parts intelligently with the limited property information that is normally supplied by many chemical companies.

Because of this lack of information on polymer properties, it was necessary for us to design a detailed evaluation program and specification.

We have conducted standard ASTM tests, borrowed and adapted test procedures of the non-standard type from others and developed a few tests of our own. The end result of this work has been the issuance of a specification for refrigerator inner doors. Work in this area will continue and the specification will be modified until we can more completely qualify the property data required for our design engineers. Our present specification, which is shown in *Table 1*, has now been in force for almost two years and has already undergone four revisions. In addition to this specification we have written Standing Instructions which cover all of the necessary test methods. A copy of these instructions is furnished to all suppliers of high impact polystyrene who are interested in developing a material that will pass our specification.

EVALUATION PROCEDURE:

A material supplier must first furnish data to prove that his material will pass the G.E. specification. The various steps in our evaluation procedure are as follows:

Step 1.

If it is decided from an examination of the suppliers' data that the material may offer some advantages, an order is placed for a lot of material manufactured on production equipment and in the current color. The vendor is then requested to furnish 50 sheets from this lot of material to meet the requirements listed in **Table 2.**

Step 2.

The laboratory conducts an evaluation for all physical properties called for under the specification. Data from this evaluation are given to the material supplier.

Step 3.

The bulk of the sheet material is concurrently processed on factory sheet forming equipment. Specific door designs are formed and submitted to the Engineering Test Laboratory for simulated service testing.

Step 4.

If the material has passed all prior tests, an order is placed for an additional lot of commercial material. This material is then processed in a factory trial run on 4½" extruders. The requirements in this step are:

a. Extruder output must pass Manufacturing standards.

b. Sheet quality must pass Manufacturing requirements.

c. Material must be capable of being reground and re-extruded five times without a major change in physical properties.

Step 5.

Sheet produced from the trial run is formed into inner doors, which are submitted to the Engineering Test Laboratory for additional testing. A complete set of physical property tests is conducted by the laboratory on all sheet variables to determine statistically if the material will still pass the G.E. specification.

If the new material passes the five steps of the evaluation program, the material is given final approval.

Discussion of Tests

Sample Preparation. To be tested, sheet materials must first meet preliminary specifications discussed under Step 1, above. All laboratory samples and tests are made only in the cross machine direction. This is contrary to industry practice, such as running tests in both directions and averaging the results or running only in the machine direction. If orientation shrinkage is less than 5%, it is probable that the cross machine direction properties are essentially the base properties for extruded sheet.

Our laboratory uses three principal pieces of equipment for sample preparation. Large sheet is sheared on a specially designed manual shear which will give a 90° cut for materials such as polystyrene. This is used to blank out the test specimens. A high speed (20,000 rpm) router (Tensil-Kut) has been equipped with a variety of fixtures for milling all of our test shapes. The only additional equipment used is a DeBell and Richardson notch cutter for notching Izod

Table 2. Preliminary Sample Requirements

a. Orientation	5% maximum
b. Commercial color match	Satisfactory
c. Dimensions	
Length (MD)	43½ inches
Width (CD)	33¾ inches
Thickness	0.115″ +0.005″ −0.000″
d. The sheet must be free from die lines, pits, gels and moisture streaks.	
e. The sheet must conform to the standards established in the ASTM specification for gloss and surface roughness.	
f. A 6″ x 15″ section of the freshly extruded sheet is wrapped as per instruction and submitted for odor and taste transfer testing.	
g. Detailed information must be furnished on material identity and extrusion conditions.	

impact specimens. Extreme care is given to the maintenance of this equipment.

Our practice is to evaluate materials in one sheet thickness, 0.115 inch. In areas where thickness dependency is critical, special tests are conducted.

Physical and Chemical Properties

The standard ASTM tests run in our laboratory against our specification *(Table 1)* are:

Tensile Strength
Elongation
Flexural Strength
Modulus of Elasticity in Flexure
Axial Fatigue (Tension-Compression)
Hardness (Rockwell)
Deflection Temperature under Load
Gloss

Styrene Monomer Content
Flammability
Toxicity
Water Absorption
Screen Analysis
Total Volatiles
Color
Surface Roughness

Non-Standard Tests

Impact and time-dependent property tests are described in papers presented at the 17th Annual Technical Conference of SPE (6), (7).

Four of our non-standard tests are described individually.

Thermal Stress. Plastic materials undergo marked dimensional changes when subjected to changes in temperature. In applications such as refrigerator inner doors, the material is not entirely free to undergo a dimensional change. Temperature changes either in shipment or in use can build up internal stresses in the material. These thermal stresses can be calculated from known values of change in modulus and thermal coefficient of expansion, but the accuracy is doubtful. Both modulus and coefficient of expansion are temperature dependent. A test was developed for measuring directly the thermal stress induced by lowering the temperature of a sample from 110°F to −20°F. A rectangular sample (6″ x 0.5″ x 0.115″) is placed in an environmental chamber and rigidly held between the grips of an Instron tester. A second sample, containing a thermocouple, is located adjacent to the test sample for recording the sample temperature. After conditioning at 110°F, a small preload is applied to the sample under test. By use of a programmer, the temperature of the environmental chamber is lowered, over a period of approximately two hours, to −20°F. The Instron recorder gives the stress increase as the temperature decreases. There is an insignificant amount of stress relaxation in the time interval of this test.

Door Slam Test. It is common practice in the refrigeration industry to conduct a door slam test on high impact polystyrene inner doors. The test is designed to simulate the repeated opening and closing of a door. It is an accelerated test that has been correlated with end use.

A door slamming machine as shown in *Figure 3* is used for this test. The machine operates at 12 cycles per minute. The operating arm of the slammer is attached to the door handle. A return bumper is used to close the door. Standard adjustments are made to inner door mounting screws, latch assembly and bumper cushion. The shelves of the inner door are loaded with lead shot in containers at a level of 0.5 lbs. per linear inch of shelf width. This test is normally run at ambient temperature.

The door slammer is stopped at given time intervals and the plastic inner door is inspected for detectable cracks or crazing. The requirements are that a new material shall pass 500,000 slam test cycles without any detectable cracks or other malfunctions.

Cyclic Racking Test. Inner doors that have been formed for test purposes are put through a second simulated service test which is called cyclic racking. The inner door is attached to an outer door which is rigidly supported by angle iron at three corners. The lower latch-side corner is not restrained. The entire assembly is shown in *Figure 4*.

The unrestrained corner is deflected away from the refrigerator until a specified load is secured. The deflection at

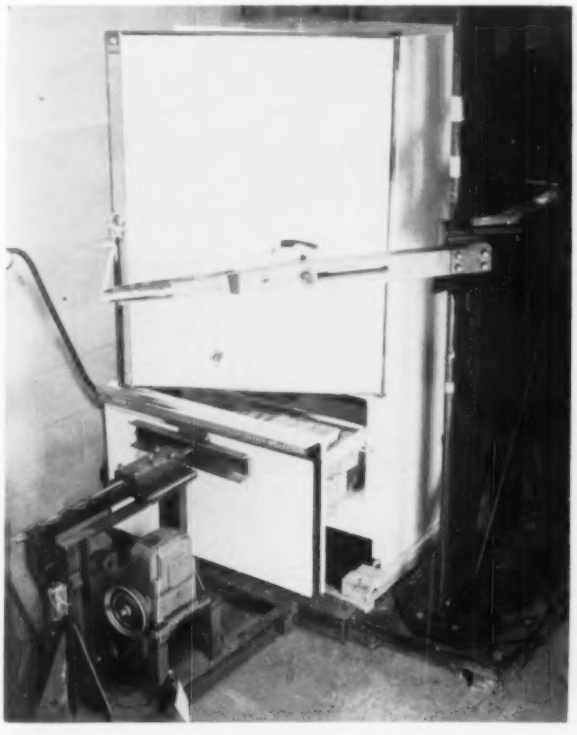


Figure 3. Door slam tester for accelerated service tests

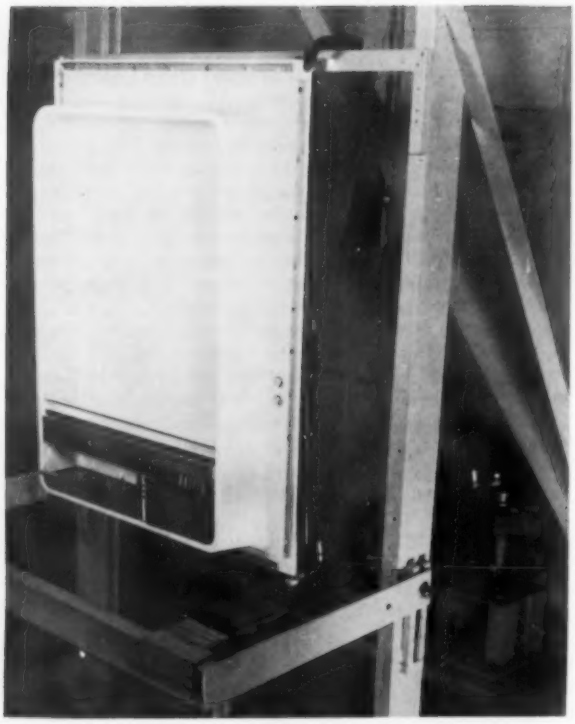


Figure 4. Cyclic racking tester measures tendency to craze and crack on flexing

this load is then recorded. A reciprocating lever arm is attached to the outer door so that it will deflect from the neutral position to the original load deflection at a rate of 30 cycles per minute.

Observations are made at given time intervals for the appearance of open cracks. The first evidence of an open crack constitutes failure and the number of cycles is recorded. Prior to an open crack, however, the appearance of crazing in several forms is generally evident and is recorded.

A refrigerator inner door must withstand 10,000 cycles at 73°F without any evidence of cracking. This test is conducted on a specific standardized door design from which we have collected a considerable amount of data.

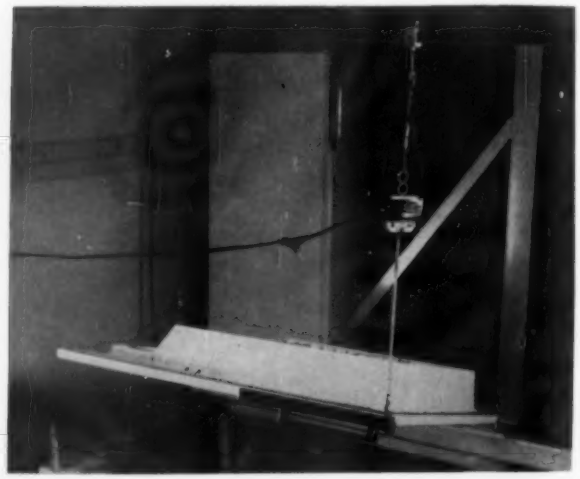


Figure 5. 0°F impact tester measures shock resistance under simulated service conditions

0°F Door Impact Test. The third simulated service test is a low temperature impact test. The inner door is assembled to an outer door omitting the door gasket and all parts which are removable by the customer. All the mounting screws are tightened to a specific torque. The assembled door is put into a 0°F room for 24 hour conditioning prior to testing. The door is mounted on a special test table with the inner door facing upward and attached to the table by the regular door hinges. The test assembly is shown in *Figure 5*. A suspending hook is attached to the upper corner of the door. The drop height is adjusted to give a specified impact energy when the door is dropped. This is expressed in ft-lbs. The door is then lifted the required distance and a quick acting release device disengages the suspending linkage which drops the door onto a stop. At the completion of the test, the door is inspected for cracks.

Summary

This article describes a detailed evaluation procedure used by one refrigerator manufacturer for testing high impact polystyrene materials for inner doors.

Tests conducted on most of the available high impact polystyrenes have demonstrated that commercial materials do differ radically in important physical properties. This is particularly true of time-dependent, impact and other properties not usually considered on standard data sheets.

A detailed specification has been written which defines materials that are suitable for application as a refrigerator inner door. The values selected by the General Electric Co. need not apply to other users of impact polystyrene for inner doors. Experience has shown that materials which will meet the specification described show definite superiority in both simulated service tests and actual field service.

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Acknowledgments

The authors wish to express their gratitude to those chemical companies and their individual contributors, who have played an important part in guiding our thinking in regard to test equipment and procedures. T. P. Foley developed the simulated service tests discussed in this paper. We also wish to acknowledge the support and encouragement of G. S. Hill and R. W. Finholt.

Chemically Cross-Linked Polyethylene

B. C. Carlson

R. T. Vanderbilt Company, Inc.

Here are processing methods for converting polyethylenes to thermoset materials with useful improvements of properties

Thermoplastic polyethylene has become one of the most widely used resins, having a wide variety of desirable properties. The growth rate of this material in the past two decades has been remarkable and the volume consumption has reached a point where it is considered the first billion pound plastic. It enjoys this position because of its good physical properties, excellent chemical and solvent resistance, excellent electrical properties, ease in processing, and relatively low material and processing costs. In spite of these desirable properties, however, it has certain deficiencies, such as poor resistance to deformation at elevated temperatures and a tendency to crack due to environmental and thermal stresses.

Within the past few years, considerable work has been done on developing methods to convert polyethylene to a thermoset material so that thermal dimensional stability and stress crack resistance are greatly improved and many of the other properties are enhanced. The two methods which have met with the most success are irradiation and chemical cross-linking as a result of peroxide decomposition.

The effect of irradiation of polyethylene has been described (1). The irradiated polyethylene has properties that would be expected for a crosslinked material. In general, an increase in radiation dosage leads to greater insolubility, to changes in tensile properties, and to better form stability at high temperatures. The crosslinking of polyethylene by irradiation requires the penetration of a relatively large amount of high energy radiation from an external source into the material, after it has been formed or shaped. This suggests relatively small volume usage at the present state of the art because of economic limitations.

Chemically crosslinked polyethylene has been of interest for some time (2). The mechanism of crosslinking involves the formation of highly reactive free radicals upon decomposition of certain organic peroxides due to heat. These free radicals, in turn, create active sites on the polymer hydrocarbon chains at which carbon-to-carbon crosslinks can occur (3). Organic peroxides of this type may decompose in two ways: free radical breakdown in a neutral or basic medium with heat, or by an ionic mechanism due to an acidic medium.

Benzoyl peroxide was one of the first organic peroxides considered for crosslinking polyethylene (4). Since this material was too reactive at polyethylene processing temperatures, other peroxides were investigated. One of the peroxides which has found wide usage in crosslinking low density polyethylene is dicumyl peroxide (5). This material becomes reactive at approximately 270°F which permits low density resins to be mixed and processed through an extruder or in similar equipment without an excessive amount of decomposition. At temperatures which are necessary for processing highly loaded low density resins and for high density resins, excessive decomposition may result in premature crosslinking either in the mixing equipment or in the extruder. In certain small diameter extrusions, there is apparently enough "holdup" time in the extruder head so that some scorching may result even with low density resins. Di-t-butyl peroxide has been suggested as a cross-linking agent. Since this material requires about 15°F higher temperature to complete the cross-linking reaction in the same length of time as when using dicumyl peroxide, it has been used to cross-link linear polyethylene. The relatively high volatility of di-t-butyl peroxide, B.P. 111°C at 760 mm. Hg pressure, however, would result in high losses of this peroxide during processing and thus limit its use.

Di peroxides (6) such as 2,5-di-t-butyl peroxy 2,5-dimethylhexane have been found to be effective cross-linking agents. This peroxide (4) has a much higher boiling point, 210°C at 760 mm. Hg pressure, than di-t-butyl peroxide. When it is used on an inert carrier, therefore, many of the problems of volatility are overcome. This material is similar to di-t-butyl peroxide in its activity in that polyethylene compounds can be processed at temperatures up to 300°F without excessive scorch or precure.

Compounding with Peroxides

Crosslinked polyethylene compositions have been formulated using a procedure similar to that used by the rubber industry. Peroxides have been used at levels similar to the sulfur-accelerator levels used in rubber compounds. The peroxide levels have, therefore, normally been at 1-5 parts based on 100 parts resin. A wide latitude of peroxide level is possible, however, depending on the type of compound and the rate and state of cure desired.

A large number of fillers may be used at many volume loadings. These would include thermal, furnace, and channel blacks and inorganic fillers such as calcium carbonate, calcium silicate, silica, clay, and alumina. Antioxidants are normally used to enhance the properties, particularly if the material is to be used at elevated temperatures for prolonged times. Elastomeric and liquid plasticizers may be added to a limited extent in order to modify the properties.

Carbon blacks have found wide commercial acceptance as fillers in cross-linked polyethylene. Since the insulated

wire and cable industry has been among the first to use cross-linked filler loaded compounds, the large particle size medium thermal blacks have been found to impart the least adverse effect on the electrical properties. Carbon blacks also impart reinforcement to the cross-linked compound which is not obtainable to the same degree with inorganic fillers. This has been postulated as an interaction between the polymer and the carbon black as a result of the peroxide decomposition (7).

When acidic materials (such as channel carbon blacks or acidic clays) are incorporated into a polyethylene compound, basic materials such as amines or inorganic bases must be used in the compound, since, as mentioned previously, in an acidic medium, the peroxides decompose without liberation of the free radicals needed for cross-linking.

Properties of Crosslinked Polyethylene

A study of the properties of chemically cross-linked polyethylene has been made. Most of this work has been done with a low density resin, DYNH-1, having a specific gravity of 0.918 and melt index of 1.7-2.4. This resin is produced by Union Carbide Plastics Company, Division of Union Carbide Corporation. The peroxides used were dicumyl peroxide [Di-Cup 40C (40% active), Hercules Powder Company] and 2,5-di-t-butyl peroxy, 2,5-dimethylhexane (TBPMH) [VAROX* (50% active)]. The antioxidant used was polymerized trimethyl dihydroquinoline [A. R. RESIN D*] and the M.T. black was THERMAX*.

The stress-strain properties of cross-linked polyethylene loaded with medium thermal carbon black at levels from 0-200 parts are compared with thermoplastic polyethylene in *Figure 1*. It will be noted that the filler has altered the stress-strain properties to a marked degree with an increase in the modulus and reduction in elongation. The change in properties of the unloaded crosslinked compound, when compared with the uncrosslinked compound, is quite significant also. It is important to note that thermoplastic polyethylene cannot be loaded with any large amount of filler before it becomes brittle and inextensible.

Figure 2 illustrates stress-strain properties obtained in a crosslinked compound with calcium carbonate[1] at three levels.

It will be noted that there is a lack of reinforcement of the type that is obtained with carbon black and that the calcium carbonate compound becomes stiff and brittle at the higher filler loadings.

The stress-strain properties of cross-linked polyethylene are dependent on the type and quantity of filler, the time and temperature of cure, and the type and amount of peroxide used. *Figure 3* illustrates the change in tensile properties of a compound composed of DYNH 100, MT black 50, poly(trimethyl dihydroquinoline) 0.5, and TBPMH content as indicated.

Although the room temperature stress-strain properties are indicative of the state of cure in cross-linked polyethylene, they have not proven to be very precise measurements, and a number of other methods have been developed. A solvent extraction method, using solvents such as toluene or xylene, has been used. The hot solvent separates the soluble portion from the gel. A high weight of gel or low quantity of extracted polyethylene is a measurement of high state of cure. High filler loadings restrict the use of this method in that filler particles contaminate the sol and also reduce the solubility of the sample.

Since crystallinity decreases as the degree of cross-linking is increased, there is also a decrease in density (7). This is more pronounced in high density than in low density resins.

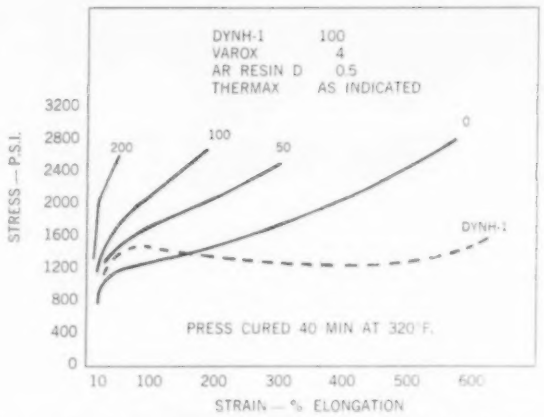

Figure 1. The effect of MT carbon black loading on stress-strain behavior

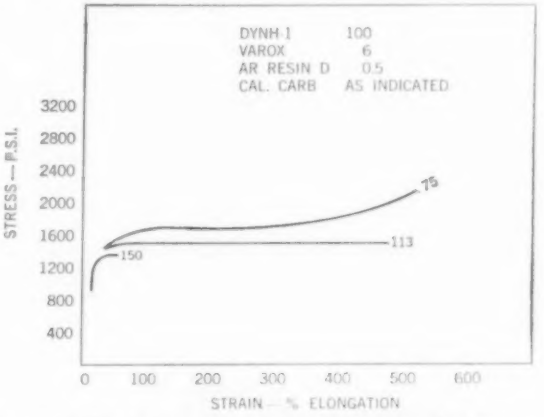

Figure 2. The effect of calcium carbonate loading on stress-strain behavior

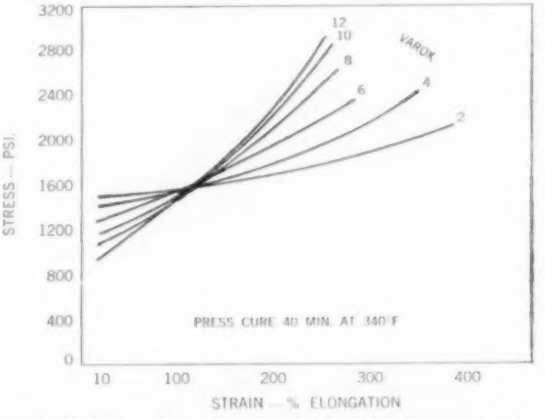

Figure 3. The effect of peroxide (Varox) content on stress-strain behavior

This property has therefore been of value in determining state of cure. The elastic modulus above the crystalline melting point of polyethylene is also a direct measure of the degree of crosslinking.

A convenient method used to determine the relative state of cure is a modification of the Williams plasticity procedure, ASTM D 926-56, whereby the per cent compression of a sample is determined at a temperature above the crystalliza-

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[1] Atomite, wet ground calcium carbonate, Thompson, Weinman & Company

Table 1. Modified Williams Compression Test Showing Effect of Crosslinking on % Compression

Formulation Tested			
Low Density Polyethylene	100	100	100
MT Black	100	100	100
Poly(trimethyl dihydroquinoline)	0.5	0.5	0.5
TBPMH 50%	—	4	6
	Per Cent Compression		
Press Form @ 320°F. 2 Minutes Press Cure @ 320°F.	**80**	—	—
10 Minutes	—	52	33
20 Minutes	—	33	14
40 Minutes	—	16	7.0
80 Minutes	—	11	3.4
120 Minutes	—	8.1	3.0

Table 2. Resistance to Solvents Improved by Crosslinking

Solvent	Per cent Change in Weight, (7 Days at 70°C.) Uncross-Linked	Crosslinked
Amyl Acetate	+10.0	+7.2
Benzene	Broken into pieces	+30.8
Methyl Ethyl Ketone	+4.0	+2.5
Nitrobenzene	+3.7	+2.8
Toluene	Broken into pieces	+40.8
O-Xylene	Broken into pieces	+44.6
Carbon Tetrachloride	Dissolved	+126.3
Trichloroethylene	Dissolved	+112.7
ASTM Oil #1	+8.8	+8.2
ASTM Oil #3	+28.6	+20.9
Turpentine	Broken into pieces	+51.6
Gasoline	Broken into pieces	+46.2
Sovasol #5	Broken into pieces	+33.1

tion point of the thermoplastic resin. In this method, a sample of 0.5 square inches in area and approximately 0.3 inch thick is prepared from four plies of a molded slab of approximately 0.075 inch in thickness. The sample is placed between the platens of a Williams plastometer maintained in a circulating air oven at 250°F. The load applied is 10 kg. The per cent compression is calculated from the height of the sample at the start of the test and the height of the sample after 30 minutes under load. The compression is compared with a thermoplastic sample which is considered a standard. This standard gives a compression value of approximately 80% in compounds containing 50-100 parts of black loading. The modified Williams per cent compression test is illustrated in *Table 1*.

It is apparent that as the cure time is increased and as the peroxide content is increased, the per cent compression is decreased. When testing low density resins, a temperature of 250°F is used. When high density resins are tested, a temperature of 300°F is used.

This test affords a convenient method of relating properties to the degree of crosslinking. Tensile strength may be related to state of cure as is shown in *Figure 4*. The tensile strength (ASTM D 412-51T—at 20 in./min.) is directly related to state of cure in carbon black loaded stocks when carbon black is used within certain volume loading limits. Medium thermal black appears to be uniquely suited as a filler in cross-linked polyethylene because of the properties developed, the high volume loadings which can be used, and the relatively low cost of this black.

Elongation at break may be related to the state of cure also and is shown in *Figure 5*. Elongation reaches a maximum at a point between a relatively low and a relatively high degree of cure when the range of carbon black filler of 50-100 parts is used. When calcium carbonate is used as a filler, *(Figure 6)* this same phenomenon appears to take place at the low loadings only, where a relatively high "stretch-out" is obtained. At high loadings a relatively low elongation and a somewhat brittle compound is obtained.

Figure 7 compares abrasion with state of cure for the same three loading levels of MT Black. Abrasion resistance was obtained on a National Bureau of Standards abrader by the RMA procedure using a standard rubber tread compound for comparison. Resistance to abrasion appears to be improved as the state of cure is increased.

Low temperature brittle point (ASTM D 736-54 T) is also related to state of cure. Again we see the advantage in developing a high state of cure in *Figure 8*. The low temperature brittle point is markedly improved by obtaining a high state of cure.

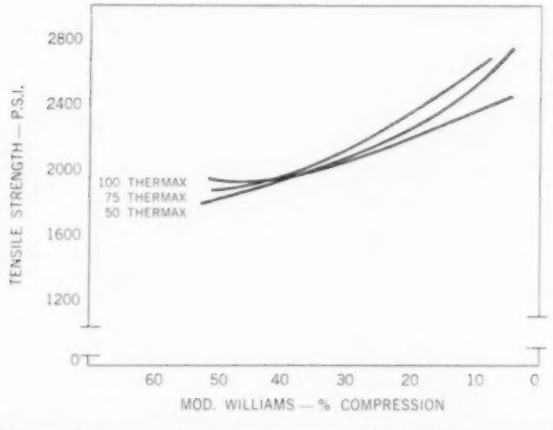

Figure 4. State of cure as measured by the modified Williams compression test governs tensile strength

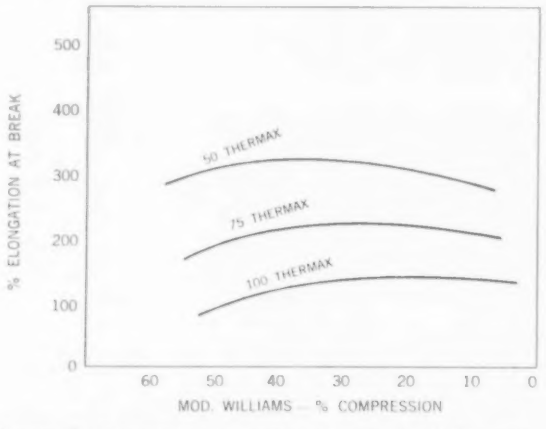

Figure 5. Elongation vs state of cure for MT carbon black loaded compounds

Solvent resistance attributed to cross-linking is shown in *Table 2*. A low density resin, DYNH, was mixed with 50 parts MT black and 0.5 part poly(trimethyl dihydroquinoline). Part of this was cross-linked with 1.75 parts dicumyl peroxide per 100 parts resin by press curing slabs for 40 minutes at 320°F. The mixture containing no peroxide was press formed ½ minute at 320°F. Change in weight of samples after 7 days in the solvent at 70°C was determined (D 543-56 T).

Cross-linked polyethylene has largely overcome one of the deficiencies of thermoplastic polyethylene stress-cracking (8). There has been no evidence in our laboratories of stress cracking due to surface active agents.

Cross-linked polyethylene does not decrease resistance to ozone attack, a property for which polyethylene is noted.

The electrical properties of polyethylene have been outstanding. This is probably the main reason for its early acceptance in the wire and cable industry. A comparison of volume resistivity (D 257-58), dielectric constant and power factor (D 150-54 T), and dielectric strength (D 149-55 T) in compounds made up of 100 parts DYNH, 0.5 part polymerized trimethyl dihydroquinoline, 4 parts TPBMH, and an MT black from 0-100 parts is shown in *Figures 9, 10, 11, and 12*. It will be noted that only in the power factor measurement is there a significant difference in the unaged results and the results after aging 10 days in air at 250°F. This may be attributed to the residual peroxide decomposition products which are quite volatile and which are largely driven off when exposed to high temperature conditions of the heat aging test.

Table 3. Aging Resistance Imparted by Antioxidants in Crosslinked Polyethylene

Formulations Tested		
Low Density Polyethylene	100	100
MT Black	50	50
TBPMH 50%	4	4
Poly(trimethyl dihydroquinoline)	—	0.5
Tensile Strength, psi (T)—% Elongation (E) Originals		
Press Cures @ 320°F.	**T** **E**	**T** **E**
10 Minutes	1980 360	1750 350
20 Minutes	2260 340	2080 390
40 Minutes	2480 320	2280 380
Aged 7 Days in Test Tubes (Air @ 121°C (250°F)		
	T **E**	**T** **E**
10 Minutes	Fused & Brittle	1750 350
20 Minutes	Fused & Brittle	2010 370
40 Minutes	1680 30	2360 360

Cross-linked polyethylene has outstanding heat resistance, particularly when antioxidants are used (9). Many of the conventional antioxidants used in thermoplastic polyethylene and in the rubber industry, however, retard the cure rate. Two antioxidants which have a minimum adverse effect on the state of cure and supply good protection from heat aging are polymerized trimethyl dihydroquinoline and di-β-naphthyl-p-phenylenediamine. Elongation and tensile strength after 7 days heat aging at 250°F are shown in *Table 3* for compounds with and without polymerized trimethyl dihydroquinoline present.

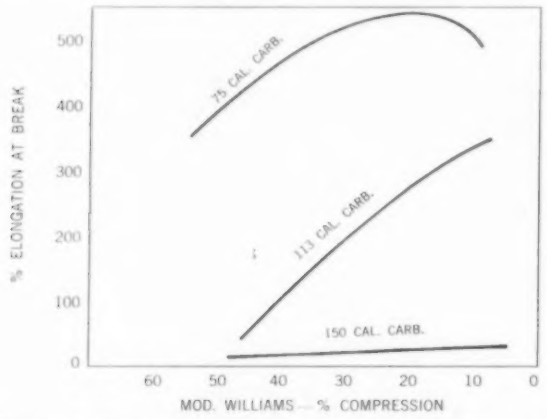

Figure 6. Elongation vs state of cure for calcium carbonate loaded compounds

Processing

Crosslinkable polyethylene may be readily handled in conventional plastic and rubber processing equipment. Since the mixing and processing temperature must be above the fluxing temperature of the resin and yet below the temperature at which the peroxide decomposes rapidly, it is

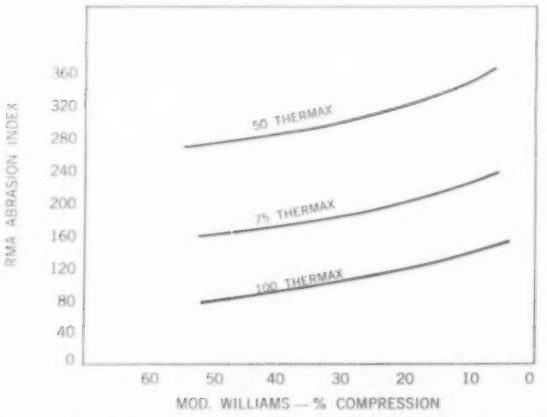

Figure 7. Improvement in abrasion resistance of black loaded compounds as state of cure is increased

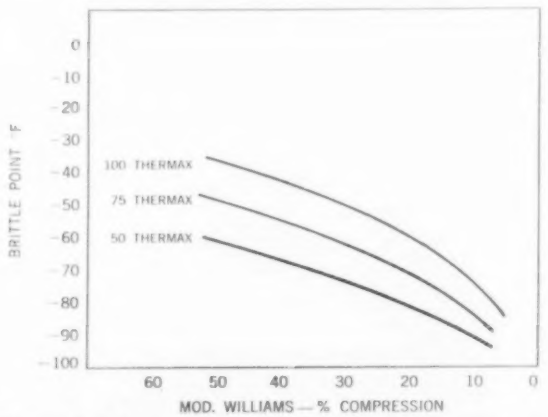

Figure 8. Effect of state of cure on low temperature brittle point

necessary to have instrumentation for accurate control of temperature. A temperature range of approximately 230-300°F must be maintained.

Most internal (Banbury) mixing equipment has the necessary temperature instrumentation but may require the addition of means of application of heat, generally by the use of low pressure steam.

The batch, which normally fluxes at 240-250°F when low density resins are used, requires an additional 10 minutes mixing time for good dispersion of the fillers. If temperature control is adequate, the peroxide may then be added, followed by further mixing for 3-4 minutes. If temperature control is not adequate, the batch may be dropped prior to the addition of the peroxide, sheeted off and ground, followed by a second cooler mix during which the peroxide is added. The second mixing, which may last only 3-4 minutes also improves the filler dispersion considerably.

Normally all ingredients except the peroxide are added initially in the Banbury. After the fluxing and dispersing cycle the peroxide is added, followed by 3-4 minutes further mixing.

The mixing procedure is tabulated in *Table 4*. A size B Banbury, 1,000-1,100 cc., equipped with steam, water, and recorder for stock temperature, was used.

The batch may also be mixed on a steam heated rubber mill. A close mill setting is necessary while the cold stock is in the bite of the mill and before it fluxes and starts to band. The mill is then opened slightly until a larger fluxed

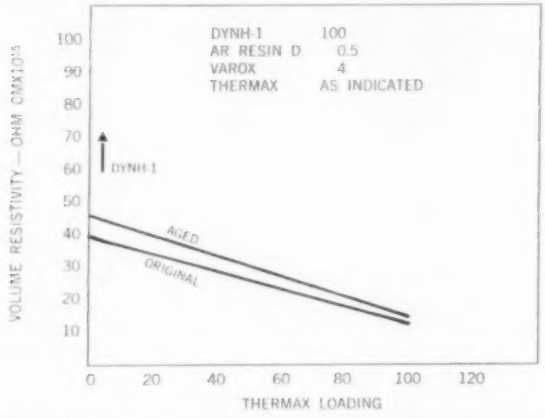

Figure 9. Volume resistivity at 70°C depends on MT black loading

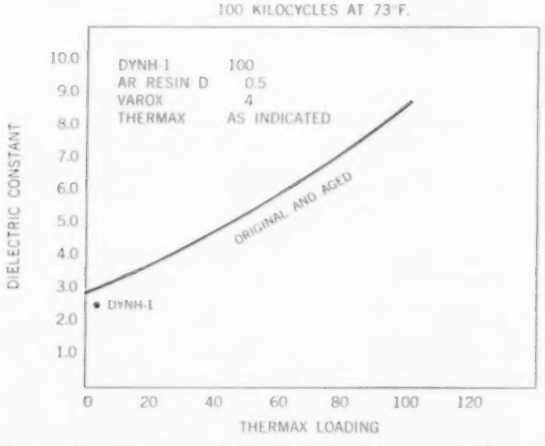

Figure 10. Effect of MT black loading on dielectric constant (100 kilocycles at 73°F)

Table 4. Mixing Procedure

	Polymer Type: Low Density Time	Low Density Temp., °F	High Density (0.95) Time	High Density (0.95) Temp., °F
1. Preblend resin, filler, antioxidant	—	—	—	—
2. Charge preblend	0	150	0	150
3. Flux (ram down, steam on)	0-3	250	0-3	280
4. Mix (ram down, steam off)	3-11	250-270	3-11	290-310
5. Add peroxide (ram down, water on)	11-14	250-270	11-14	290-300
6. Discharge on mill (rolls heated as indicated)	—	210	—	270

Table 5. Mooney Scorch and Viscosity @ 270°F

Formulations Tested			
Low Density Polyethylene	100	100	100
Poly(trimethyl dihydroquinoline)	0.5	0.5	0.5
MT Black	50	75	100
50% TBPMH—4 Parts			
Scorch T5	46	48	50
Viscosity—M L	9.5	11	14
50% TBPMH—6 Parts			
Scorch T5	37	37	35
Viscosity—ML	9	11	15

Table 6. Mooney Scorch and Viscosity @ 300°F. vs. Melt Index

	0.4 MI	2 MI	20 MI
Low Density Polyethylene	100	100	100
MT Black	50	50	50
Poly(trimethyl dihydroquinoline)	0.5	0.5	0.5
TBPMH 50%	4	4	4
Scorch T5	9	13	26
Viscosity—ML	10	5	1

bank is formed, when the mill rolls may be opened still further. A mill roll surface temperature of 200-220°F. is desirable.

Powdered forms of polyethylene resins are now supplied by a few companies. The dry blending of powdered resins, fillers, antioxidants, peroxides, and other additives followed by the fluxing and mixing directly in the extruder is being considered. By this technique the mixing in a second piece of heavy equipment is eliminated.

Since the rubber industry, particularly the wire and cable manufacturer (10) was probably the first to take a commercial interest in this material, many of the testing and processing techniques and methods are those used by the rubber industry. The Mooney scorch and viscosity tests are part of these. Polyethylene batches vary in their viscosity during the mixing cycle. The maximum viscosity is reached when

the stock is going through the fluxing stage. Above this point, the viscosity drops. The viscosity is also highly dependent on the melt index of the resin and on the type and quantity of filler. After the peroxide has been added, the viscosity will also rise if there is peroxide decomposition as a result of premature cross-linking.

The Mooney scorch and viscosity data for compounds of different filler loadings and peroxide content are shown in *Table 5*. These factors must be considered in processing also.

Table 6 illustrates the difference in scorch time and Mooney viscosity of three compounds made up from resins of different melt indexes. It is apparent that scorch time is markedly reduced when low melt index resins are used at the same level of peroxide. Although there are processing advantages to be gained by using high melt index resins, the loss in physical properties and open steam curing problems, such as sagging, swelling, and porosity, limit the extent to which high melt index resins can be used.

Following mixing in a Banbury, the compound is dropped onto a sheet-off mill. Mill rolls should be controlled at about 200-220°F for low density resins and 250-275°F for high density resins. The stock is generally strip fed from the sheet-off mill, through a cooling tank, and ground or diced so it may be fed into extruders or other processing equipment.

The material has been extruded successfully, using both plastic and rubber machines, with screws having a relatively high length-to-diameter ratio being preferred. Accurate temperature instrumentation and control are necessary. The temperature settings in the various zones of the barrel may vary considerably, depending on the temperature control, type of loading in the stock, the peroxide used, and the actual rate of extrusion. The temperature of the stock in the extruder must be in the range of 240-260°F for low density resins in order to bring it above the fluxing temperature. This may require extruder settings anywhere in the range of 200-250°F. The extruder head and die temperature should be in the range of 250-270°F, depending on the stock viscosity and the peroxide used.

Curing of crosslinkable polyethylene compounds has been a problem for some applications. Open steam curing in continuous vulcanization equipment was readily adapted from the wire and cable industry where the wire acted as a support while the material was drawn through the vulcanizer. Several continuous methods of curing pipe are being considered including high pressure open steam, molten metal, and electric induction. Shorter lengths may be mandrel supported and wrapped or lead coated for open steam cures in a vulcanizer.

Compression molded products are readily produced. In some cases the mold must be cooled in order to obtain an undistorted product.

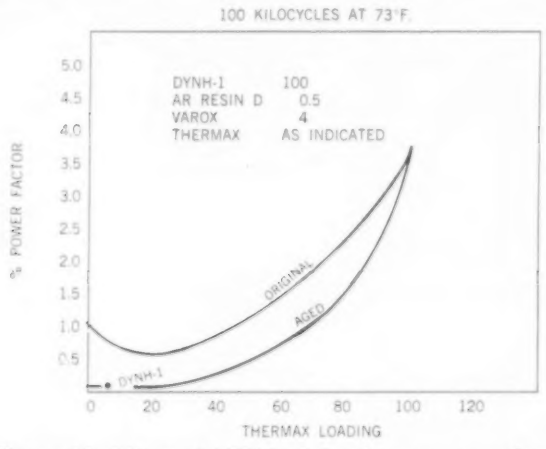

Figure 11. Effect of MT black loading on power factor. (100 kilocycles 73°F)

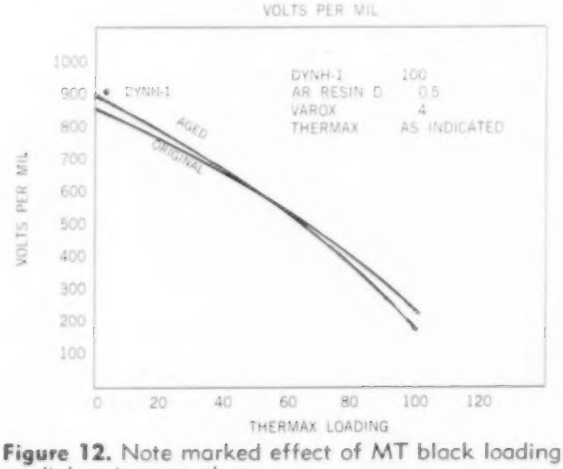

Figure 12. Note marked effect of MT black loading on dielectric strength

Summary

Thermoplastic polyethylene may be cross-linked by certain organic peroxides through a free radical mechanism. A few peroxides used for cross-linking low and high density resins are discussed. Compounding of cross-linked polyethylene, including the use of carbon black and inorganic fillers, and antioxidants are reviewed. Medium thermal carbon blacks have been used extensively in cross-linking polyethylene compounds.

The state of cure is measured by a heat compression test which measures the deformation of the cross-linked sample at a temperature above the crystallization point of the resin. The state of cure is related to stress-strain, abrasion, and low temperature properties. Other properties of cross-linked polyethylene compounds such as electrical, solvent resistance, and resistance to heat oxidation are outlined.

Chemically cross-linked polyethylene is processed in conventional rubber equipment. This material is now firmly established in the wire and cable industry and there is a lot of interest for the use of crosslinked polyethylene in pipe, hose, sponge, and molded goods.

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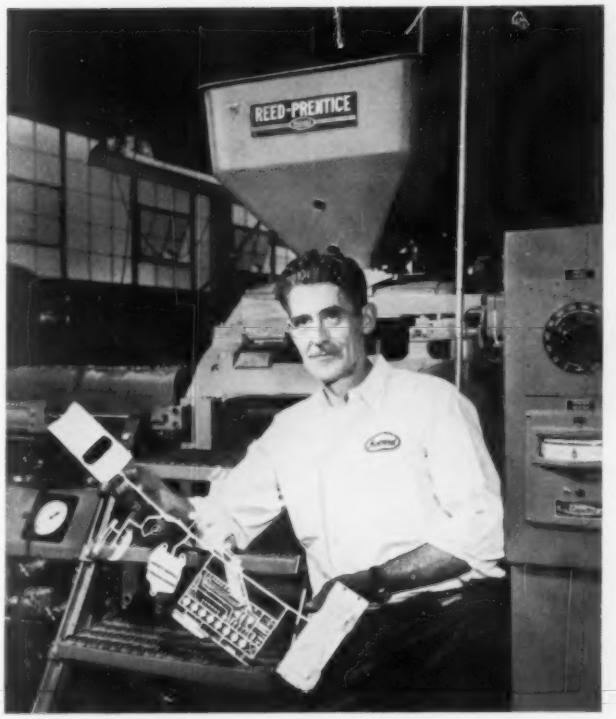

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Two panel discussions are planned: (1) Safety, Codes and Money, and (2) Construction Needs, Can they be filled by Plastics? Among the speakers and panelists will be Mr. Earl Ziegler, Dow Chemical Company, Midland, Michigan, who will speak on "Plastics for Today's Construction Industry" and Mr. Karl Kamrath of MacKie and Kamrath, Houston architects.

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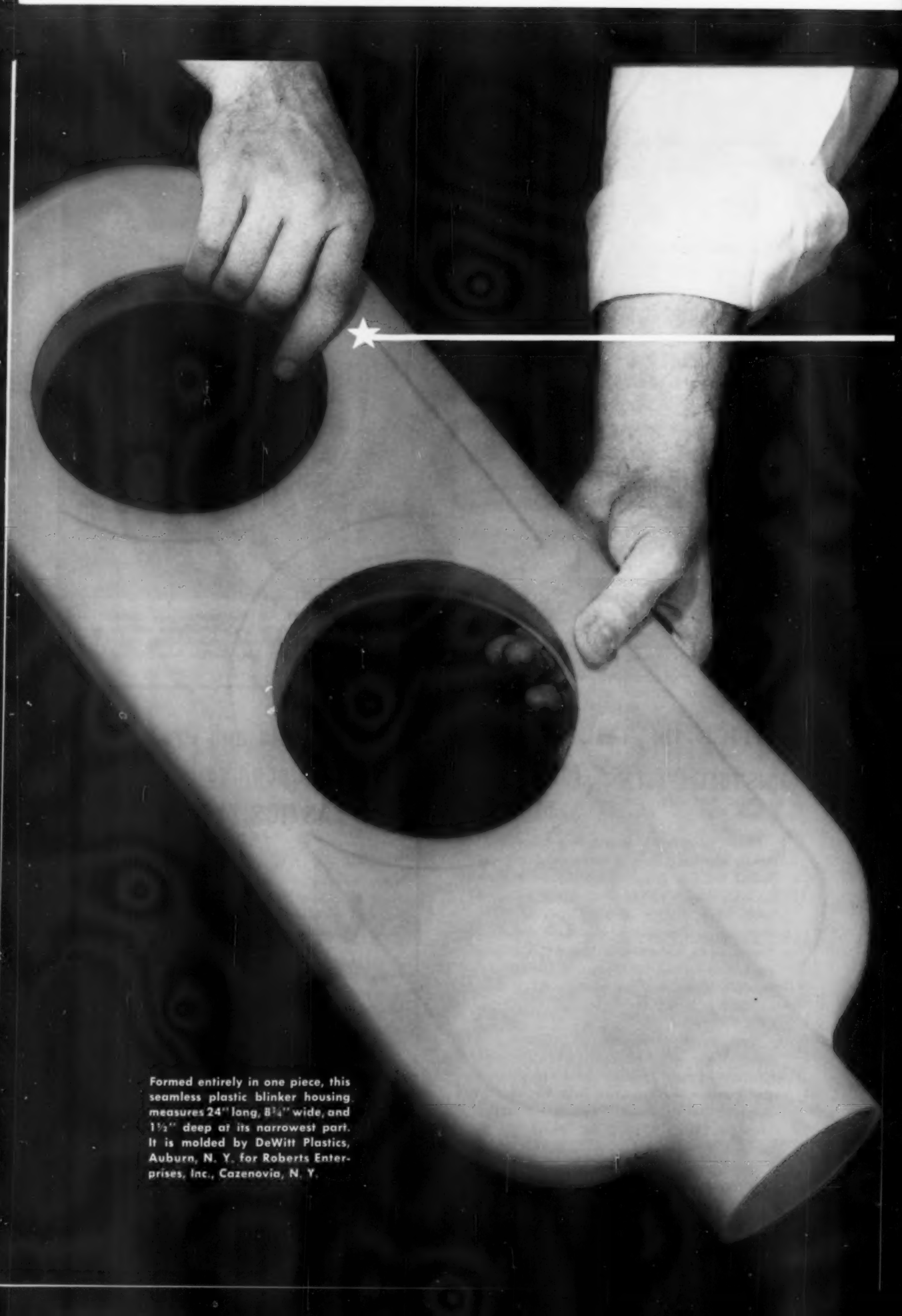

Formed entirely in one piece, this seamless plastic blinker housing measures 24" long, 8¼" wide, and 1½" deep at its narrowest part. It is molded by DeWitt Plastics, Auburn, N. Y. for Roberts Enterprises, Inc., Cazenovia, N. Y.

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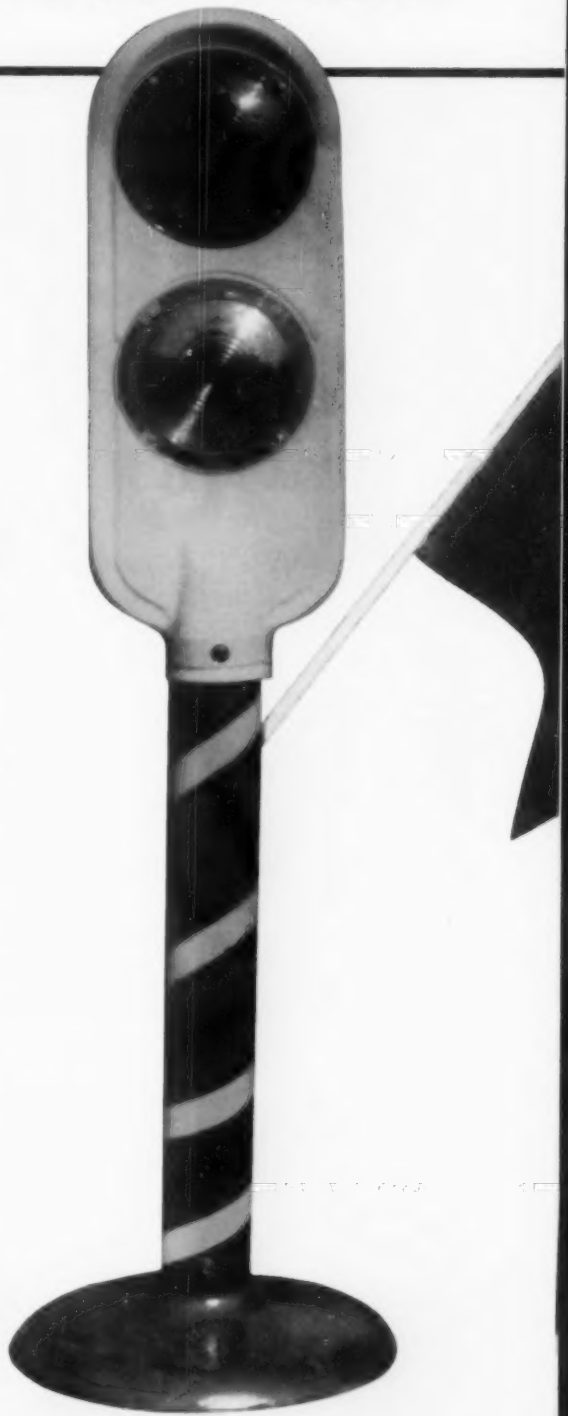

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More than 2500 plastics engineers, scientists, and technical service men braved the snow and converged on Washington, January 24-27, 1961.

Injection Molding PAG. Main ballroom is filled as audience hears discussion on preplasticizing in injection molding

WASHINGTON HOSTS
17th Annual Technical Conference

Technical sessions featured over 100 papers, covering subjects ranging from irradiation of polymers to reinforced plastic turbine compressor housings. In addition to the technical sessions, the Society's Professional Activity Groups held productive sessions, with three PAG's holding special events—the Thermosetting PAG sponsored a guest lecture by Dr. A. M. Howald on the Molding of Alkyd Materials, the Injection Molding PAG held a panel discussion on preplasticizing, and the Vinyl Plastics PAG sponsored a panel discussion on Vinyls in the Automotive Field. The accompanying photographs show some of the activity at the Conference.

Award. G. Palmer Humphrey accepts coveted President's Cup for outstanding service to the Society. George W. Martin, 1960 President, makes the presentation at the Banquet

Goals. Frank W. Reynolds, SPE President, outlines goals for 1961

SPE's 1960 COUNCIL

First Row (seated)—F. L. Fine, T. A. Bissell, F. C. Sutro, Jr., J. R. Lampman, G. W. Martin, President, F. W. Reynolds, President-Elect, J. A. Schmitt, H. S. Nathan and D. Eells

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ANTEC Committee. Pictured are members of the Baltimore-Washington Section members of the ANTEC Committee which was mainly responsible for success of Conference. Left to right: Stanley Prosen, Taylor Birckhead, Frank Reinhart, Gordon Kline, General Chairman, Robert Stromberg, Joseph Mazia, Lawrence O'Rourke, Casmir Plasewicz. Other Committee members not present when picture was taken: Albert Lightbody, Henry Perry, Myron Defries, Irvin Wolock, Edward Ditz, Walter Hourt, Shelton Moore, and Daniel Nitzberg

Thermosetting PAG hears how to mold alkyd materials

PAST PRESIDENTS' ADVISORY BOARD AND GUESTS

Standing for group picture in Washington are, left to right: Jerome L. Formo (1956), Peter W. Simmons (1957), Frank W. Reinhart (1955), Frank W. Reynolds (SPE President), William O. Bracken (1952), Frederick C. Sutro, Jr. (1959), Isyln Thomas (1951), George W. Martin (1960), Thomas A. Bissell (Executive Secretary), and Jesse H. Day (SPE Journal Editor Emeritus).

Education. Dr. E. W. Comings, Dean of Engineering, University of Delaware tells Education Luncheon audience that all engineering curriculums must have basic science courses in common

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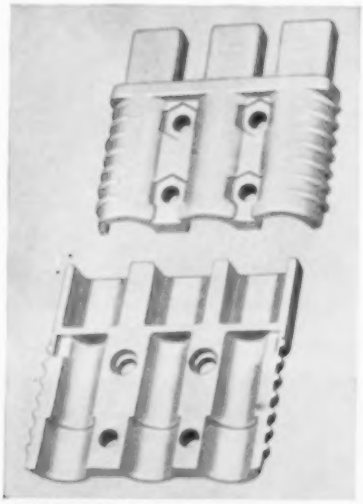

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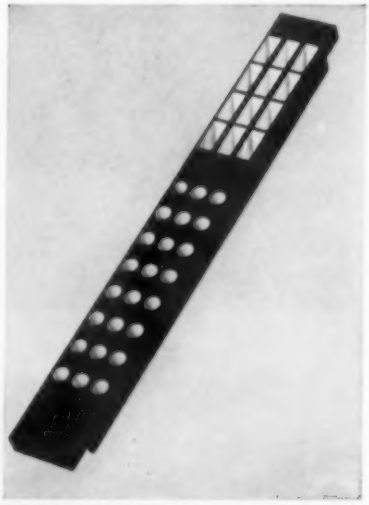

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MODERN SCIENCE DICTIONARY

A. Hechtlinger (Franklin Publishing Co., Inc., Palisade, N. Y. 1959, 784 pp. $10.00)

This Dictionary was first prepared for high school students, but, as the Author states: "The greatest problem was what to include and what to omit. It is hoped, however, that a fair balance was reached among the many subjects covered". It can be said that this compilation is very satisfactory for the student and the technical adult as well. The selection is sound and practically every word one expects to find in a lexicon of this size has been put in. Furthermore, the definitions are clear, explicit and adequate, contrarily to those which appear in dictionaries and encyclopedias.

There are a few good illustrations: unfortunately they are lost in the text as they are not mentioned at the word they illustrate, and there is no table at the end of the book. This can be easily corrected of course.

The numerous fields of science this dictionary covers make it very desirable to any scientist and technical man. Do not miss it.

Dr. Louis C. Barail
Barail Associates

NON-CRYSTALLINE SOLIDS

V. D. Fréchette, Editor, Conference on Non-Crystalline Solids, Alfred, New York, September 3-5, 1958, John Wiley & Sons, Inc., 530 pp., $15.00.

Here is a book that comes but once in too long a period. It is a collection of the highly technical papers presented at the 1958 Conference on Non-Crystalline Solids at Alfred, New York, edited and assembled in a manner that makes it an excellent source of information for practical use by the research scientist.

The first five chapters deal with the scattering of radiation by non-crystalline materials, including x-ray and light diffraction. Chapters 6 to 8 discuss electronic structure, molecular structure, motions of molecules and groups, chemical bonding, and electronic configurations in paramagnetic solids, with special reference to glasses.

Chapters 9 to 12 deal with relaxation phenomena, developing the kinetics of mechanical relaxation effects in inorganic glasses in relation to internal friction, strain retardation, and impact methods of study at appropriate temperatures.

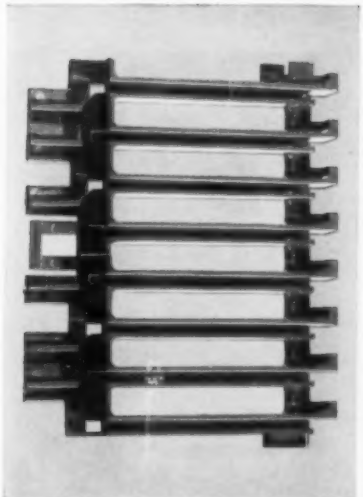
NEW BOOKS

The last eight chapters are concerned with the structure and properties of special systems. This includes kinetics of ion movement in thin films, optical absorption, electrical conductivity and superconductivity, and x-ray and electron diffraction measurements, as well as a number of other studies of the various anomalies and phenomena in specific heat, shear modulus, refractive index, thermal expansion, ultrasonic and dielectric relaxation, and bulk modulus.

In summary, the book is not designed for the everyday working plastics engineer, but it will open to him the doors of a vast temple of knowledge, enabling him to understand the microcosm that underlies his profession.

Samuel S. Oleesky

BONATE RESIN TOUGHEST OF PLASTICS!



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THE PRINCIPAL THERMO-FORMING RESINS—COMPRESSION MOLDED PHENOLICS, UREAS, AND MELAMINES

Dr. Luis Passini, Plasticos, Argentina, July-August, 1960, 110-119 pp.

The three principal thermosetting resins, melamine, urea formaldehyde, and phenol formaldehyde, formed by condensation reaction polymerization, are discussed in the article

The author describes what he believes to be the six or seven most important components for obtaining a good compression or transfer molded article.

Each component is discussed at length. The list includes the resin, catalyst, colorants, lubricants, brighteners, and the effect of blending before compression molding.

M. G. Bourne, Jr.

COMPRESSION AND TRANSFER MOULDING OF PLASTICS

J. Butler, A. M. I. Mech. E., (Iliffe & Sons Limited, London; Interscience Publishers, New York, 230 pp., $5.75)

The book is divided into eighteen sections dealing with mold and tool design, engineering principles and the types of material best suited for Compression and Transfer Molding. There is an abundance of excellent mold sketches and photographs concerning various methods of 'getting that good shot'.

Perhaps, we who "know it all" about transfer and compression molding should take the opportunity to study this well written book. Although, as the author states in the preface, this book was written for the student in school, or the apprentice in the toolroom, our suggestion is that mold designers, shop foremen, toolmakers, estimators and even the plant owner, along with the teacher in school, peruse the contents as a refresher and as an interesting source of new information.

The only minor shortcoming of this book is the fact that the English technical terminology is somewhat different from ours, but even this shortcoming does not affect the material value.

Irving H. Kellman

POLYPROPYLENE

Theodore O. J. Kresser (Reinhold Publishing Corp., 264 pp., $6.50)

In writing a book about a subject and material as new as polypropylene, Mr. Kresser has undertaken a difficult assignment. However, he has accomplished his task very well. The book "POLYPROPYLENE" serves as a complete collection of the work done by the many people in the industry and covers about every phase of polypropylene.

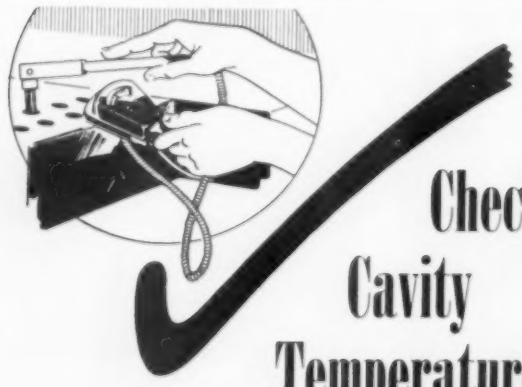
A major portion of the book pertains to applications and markets for polypropylene.

Even though new and improved polypropylenes will make their appearance on the market along with new processing techniques, this text will continue to serve as a useful guide, and from the fabricator's standpoint, a good insight can be gained as to the basic principals involved.

For those concerned with the marketing of polypropylene, the section on applications should be of great interest.

"POLYPROPYLENE" as a reference book can be highly recommended.

W. L. Dunkel



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Send for bulletin 194–S

CAMBRIDGE INSTRUMENT CO., INC.
1668 Graybar Bldg., 420 Lex. Ave., N.Y., 17, N.Y.

CAMBRIDGE
MOLD • NEEDLE • ROLL
PYROMETERS

Bulletin 194—S gives details of these instruments. They help save money and make better plastics.

KILL STATIC WITH A GUN!

Simco Ionizing Air Guns will put an end to static woes in any finishing operation! Plastic parts are blown clean, while being neutralized, so that dust, dirt and lint are *completely* removed and will not be reattracted! This new electronic air gun is safe, easy to use, and *guaranteed* effective! Write for facts.

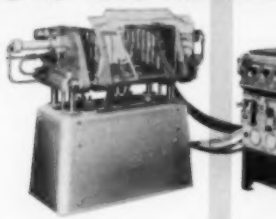
the SIMCO company
920 Walnut Street, Lansdale, Pa.

The Rainville Company has the most complete selection of plastic equipment!

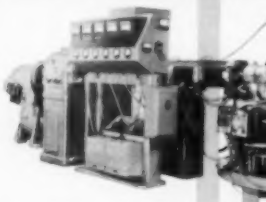
Management and Personnel at a recent sales meeting

Rainville Research and Development Laboratory

BLOW MOLDING

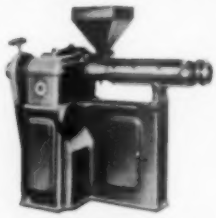


1. ½ Gallon Blow-O-Matic Rising Mold Type Machi



5. Rainville Rotary Blow Molding Machine—6 Statio with TRS 80—3¼" Luigi Bandera Extruder with do

EXTRUSION EQU



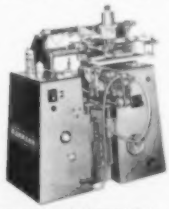
9. TR 30 (1⅛") Bandera Extruder

10. T

14. Vern Emery Saw—Model 4 cuts up to 4" pipe

15. V up to

PRINTING & MAR



19. Kammann K 10 Manual Silk Screening Machine for round objects such as blown bottles

20. K Bottle

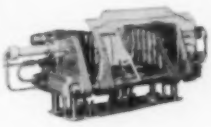
FOREMOST SCR

24. 3C-2 Hi-Shear Grinder— 10" x 12" Throat; 3 or 5 hp motor

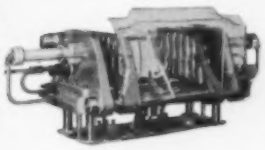
25. H 8½"

NG EQUIPMENT

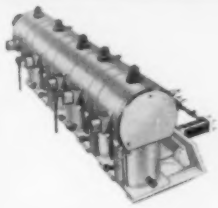
Machine



2. 2½ Gallon Blow-O-Matic Table

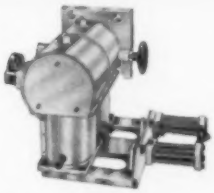


3. 5 Gallon Blow-O-Matic Table

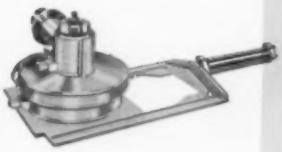


4. 1½" Parison Head—5 Station

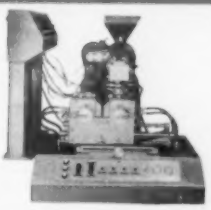
S Station—1000 per hour dry cycles, with double zone extrusion head.



6. 2" Double Head—Adjustable Parison Wall

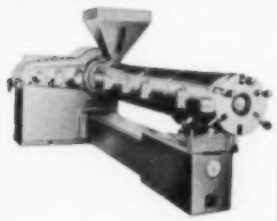


7. 15" Single Crosshead



8. S.C.A.E. (made in Italy) One Size —One Quart—1200 Dry Cycles— Air Operated

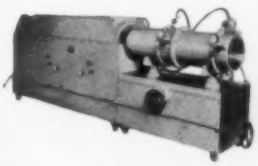
QUIPMENT



10. TR 120 (4¾") Bandera Extruder

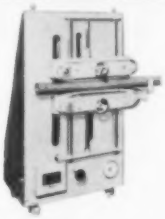
11. Rainville 2½" Extruder—20 to 1 L/D Ratio—42" Centerline— Standard Arrangement

12. Rainville 2½" Extruder—20 to 1 L/D Ratio—Base Arrangement for Blow Molding

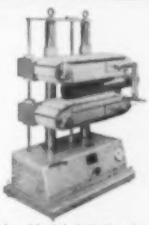


13. Bandera Vacuum Pipe Sizer

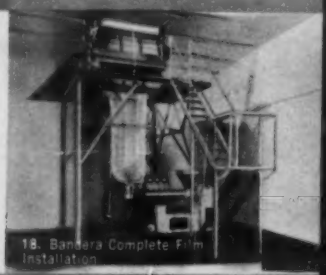
15. Vern Emery Saw—Model 9 cuts up to 9" pipe



16. Speedex Model 0/3 Puller

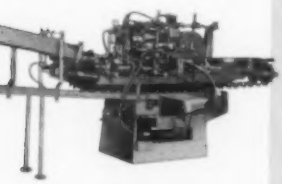


17. Speedex Model 0/5 Tractor-Type Haul Off (up to 5" capacity)



18. Bandera Complete Film Installation

ARKING EQUIPMENT



20. Kammann K 5 B Fully Automatic Bottle Silk Screening Machine

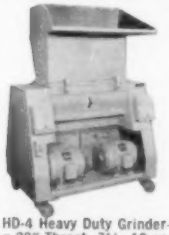
21. Kammann K 11 Automatic Sidewall Printer

22. Rainmark Model 25 High Capacity Rotary Hot Stamping Machine

23. Rainmark Model 30 Reciprocating Table Hot Stamping Machine

CRAP GRINDERS

25. HD-1 Heavy Duty Grinder— 8½" x 10" Throat; 3 or 5 hp motor



26. HD-4 Heavy Duty Grinder— 10" x 28" Throat; 7½, 10 or 15 hp motor

27. HD-2 Grinder Equipped for Pipe Grinding

28. Heavy Duty Model 6B Lump Cutter

Where to phone or write

GARDEN CITY, NEW YORK
839 Stewart Avenue
Pioneer 6-7135
Dewey Rainville
Robert Shevett
John Mann
Ed Schumers
Henry Shevett

STAMFORD, CONNECTICUT
15 Brooklawn Avenue
Davis 4-2257
Thomas Ryan

WOODSTOCK, CONNECTICUT
West View Drive
Walnut 8-3860
Larry Franks

IRVINGTON, NEW JERSEY
1016 Clinton Avenue
Essex 4-7440
Allan Niebuhr
Judson Graham
Robert Campus

ABINGTON, PENNSYLVANIA
Turner 4-7833
Harry Harp

FRANKLIN, PENNSYLVANIA
Idlewood 2-3722
John Reib
Dick Reib
Charlie Worden

EVANSVILLE, INDIANA
127 Locust Street
Harrison 4-9631
William Sherwood

DETROIT, MICHIGAN
3258 Outer Drive East
Forest 6-7670
Robert Markey

EVANSTON, ILLINOIS
839 Chicago Avenue
Greenleaf 5-2203
Robert Brandt

MINNEAPOLIS, MINNESOTA
252 Plymouth Avenue North
Federal 6-0032
Edward Berman

ST. LOUIS, MISSOURI
1315 Cheshire Lane
Woodland 2-1721
Val B. Heisel
Royal E. Fisler

FORT WORTH, TEXAS
P. O. Box 11383
Walnut 6-3622
Milton Hamill

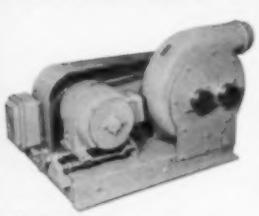
ALHAMBRA, CALIFORNIA
1420 South Garfield Avenue
Cumberland 3-4465
A. D. Rainville
Harold Putsey

RAINVILLE RESEARCH AND DEVELOPMENT CORPORATION
839 Stewart Avenue
Garden City, L. I., New York
Pioneer 6-7135
Henry Thielfoldt
John Stracey
Stanley Currans

The Rainville Company, Inc.

839 Stewart Ave., Garden City, L. I., New York

FOREMOST AUTOMATIC SCRAP H



29. Cutter Blower for automatic removal of sheet edge trim

30. Under-the-Press Grinder-Blender-Loader. Scrap inlet height as low as 16" from ground

31. 3C-2 Ro
grinding scr

LOADING AND MIXING

35. Foremost 1" Automatic Hopper Loader including Level Switches, Drum Clamp, Solenoid Valve, etc.

36. Rainco Drum Tumbler with Floor-Level Loading

37. Rainco

DRYING AND DEHUMIDIFYING

41. Dehumidified Hopper Dryers. A complete line of efficient dryers from 50 to 1000 lbs. per hour

42. Una-Dyn Hopper Dryer complete with efficient air distribution hopper and dust-free Rainco Vacuum Loader

43. Una Dyn
Loading Com
Loader

MOLD TEMPERATURE CONTROL

47. Rainkool Refrigerating and Recirculating Units—Air Cooled and Water Cooled

48. Autotherm Model 801 Single Zone Mold Temperature Control Unit—50 degrees F to 230 degrees F

49. Autotherm
Mold Tempera
50 degrees F

ROTARY COMPRESSION MOLDING

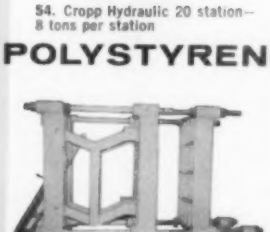
53. Cropp 20 station—3½ to 10 tons per station. Fully automatic continuous compression molding with powder or preforms.

54. Cropp Hydraulic 20 station—8 tons per station

55. Cropp Rotar

EXPANDABLE POLYSTYRENE

59. Slocomb Expandable Polystyrene Steam Expander—Model 2 shown. Available in 3 sizes



60. Rainco Expandable Styrene Molder

MISC

61. Rainville Gr
ferrous metal co

P HANDLING SYSTEMS

C-2 Roll-Feed Grinder for
ng scrap in roll form

32. Plant installation of complete automatic Grinder-Blender-Loader for film

33. Adapter Unit and Impeller Loader to convert any standard grinder to an automatic Grinder-Blender-Loader

34. Model 3XX Grinder with variable speed feed roll for light gauge sheet

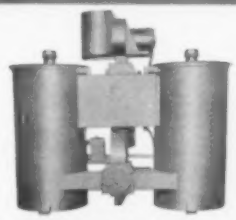
ainco Flake Loader

38. Rainco Standard Vacuum Loader —1200 pounds per hour capacity

39. Rainco High Capacity Vacuum Loader—1800 pounds per hour capacity

40. Rainco Loader with Dust Tight Mounting

na Dyn Model AO-2—Floor
g Combination Dryer-Hopper
r



44. Model AM-15 Molecular Sieve Dehumidifier

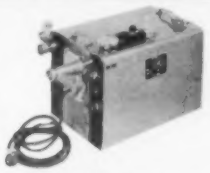
45. Foremost 20—Tray Oven

46. Foremost 40—Tray Oven

otherm Model 802 Dual Zone
emperature Control Unit—
rees F to 230 degrees F

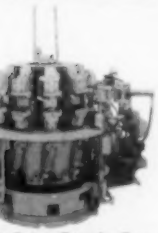
50. Autotherm Model 805 Single Zone Atmospheric Pressure Unit—4500 Watt Control Unit—50 degrees F to 210 degrees F

51. Autotherm Model 807 Dual Zone Hot Oil Mold Temperature Control Unit—100 degrees F to 500 degrees F

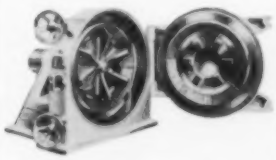


52. Autotherm Model 810 Cooling Only Unit for Vacuum Forming or Extrusion Screw Cooling for Use on Water Only—50 degrees F to 210 degrees F

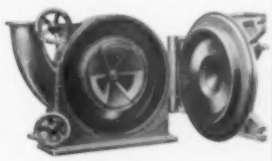
NG FINE GRINDING EQUIPMENT



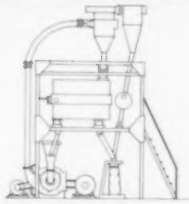
p Rotary Transfer Press



55. Pallmann PP 6 for "powdered" thermoplastics down to 100 mesh without refrigerant

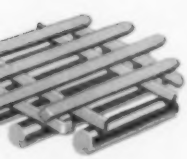


57. Pallmann RF 8



58. Pallmann complete plant installation with automatic screening

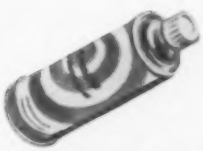
SCELLANEOUS



ville Grate Magnets for
netal contamination

62. Mayhew Oil Reconditioner—Model MT-1

63. Model 30 Doyle Vacuum Cleaner



64. Rainville Mold Release

1 to 4 cases	$12.00 per case
5 to 9 cases	11.50 per case
10 to 24 cases	11.00 per case
25 to 49 cases	10.50 per case
50 or over	10.00 per case

So that you can get the information you want in the shortest possible time, we suggest you write directly to the company address listed at the end of each new product item.

New Materials and Equipment

MATERIALS AND APPLICATIONS

Heat-Resistant Fiber

An all-organic, heat-resistant fiber retains its flexibility and part of its strength after exposure to temperatures as high as 18,000°F. Available as a fabric, it can also be used as a reinforcement in phenolic laminates. In laminate form, about 50-50 combination with phenolic resin is suitable for structural parts requiring intense heat resistance. *Dept. SPE,* **Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn.**

Silicone Varnish

A new varnish that cures at 105°C in six hours eliminates the need for high-temperature curing ovens in producing Class H electrical equipment. The manufacturer reports that the new varnish has greater heat stability than any other varnish known. Run off is also said to be lower. *Dept. SPE,* **Dow-Corning Corp., Midland, Mich.**

Phenolic Laminates

Two new flame retardant phenolic laminates are said to provide the processor with new applications possibilities. They are particularly suitable as insulating bases for many printed circuit applications previously demanding the use of the more expensive epoxy paper laminates. The manufacturer also suggests use of these laminates as a substitute for epoxy resins because of their excellent dielectric properties. *Dept. SPE,* **Panelyte Division, St. Regis Paper Co., 150 East 42nd St., New York 17, N. Y.**

Red-Violet Pigment

A new quinacridone pigment with a brilliant red-violet hue is available for use in automotive and other industrial finishes, printing inks, vinyl products, and plastics. The pigment gives fiery red shades with molybdate orange, clean pastel tones with titanium dioxide, and bright iridescent red-violet shades with nonleafing aluminum. *Dept. SPE,* **Allied Chemical Corp., (Dept. P.R. 88), National Aniline Div., 40 Rector St., New York 6, N. Y.**

Plastisol Stabilizers

Two new stabilizers have been designed specifically for organosols and plastisols. The manufacturer reports that they function by the synergistic action of metallic and non-metallic stabilizing components. Both stabilizers are light amber liquids of "A" viscosity. *Dept. SPE,* **Ferro Chemical Division, P.O. Box 349, Bedford, Ohio.**

Fungus-Resistant Plasticizer

Vinyl films can be made fungus resistant with a new epoxy plasticizer-stabilizer, reports the manufacturer. The new plasticizer is expected to increase the utility of vinyl resins for pond liners, floor tile, shower curtains, building covers, and other products subject to fungus attack. Chemically, the new product is di(isodecyl) 4,5-epoxy tetrahydrophthalate. Price is 40 cents a pound, delivered in tank car lots. *Dept. SPE,* **Union Carbide Chemicals Co., 270 Park Ave., New York 17, N. Y.**

Copolymer Latex

A new film-forming styrene copolymer latex, to coat paper and paperboard for drinking cups, disposable containers and food packages, has been introduced. The new material is said to provide a continuous, non-blocking, clear coating with excellent resistance to hot and cold liquids and grease and oils. *Dept. SPE,* **Monsanto Chemical Co., Springfield, Mass.**

Self-Extinguishing Epoxies

Two self-extinguishing epoxy resins have been announced. Both are made by substituting bromine atoms on the epoxy molecule. Common curing agents can be used. Possible uses: Laminated aircraft structures, glass and paper-based laminated electrical circuits, filled castings, and in adhesives. Physical and electrical properties of castings and laminates of the new resins are comparable to conventional epoxies. *Dept. SPE,* **The Dow Chemical Co., Midland, Mich.**

Vinyl Chloride Resin

A vinyl chloride resin tailored especially for heavy gauge sheeting has been developed. The material is a cold blending or "blotter" type resin. It can be preblended at room temperature and will absorb high amounts of plasticizers to form a fairly dry, free-flowing mixture without heating. *Dept. SPE,* **Goodyear Tire and Rubber Co., Akron 16, Ohio.**

Phenolic Coating Resins

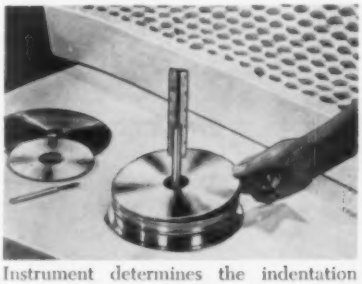
Three phenolic resins recently developed are reported to be ideally suited for the production of varnishes by the cold-mix technique. They are available in free-flowing granulated form and are packed in 50-pound polyethylene-coated multiwall bags. Production is said to be speeded up because the granulated resins melt faster in the kettle. *Dept. SPE,* **Union Carbide Plastics Co., 270 Park Ave., New York 17, N. Y.**

EQUIPMENT

Dry Feeders

A new series of pre-engineered dry feeders are available for use with pulverized, powder, or granular dry materials in the chemical or plastics fields. Feeders feature reinforced machined casings, corrosion-resistant linings, and a channel base that takes the motor load off the feeder casing. *Dept. SPE,* **Tower Iron Works, 60 Borden St., Providence 5, R.I.**

Foam Tester



Instrument determines the indentation compression or firmness of: Rubber latex, urethane and vinyl foams. Tests are made through a tiny slit in the foam sample. Results are obtained in regulation ASTM, RMA, and SPI units. *Dept. SPE,* **Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N.Y.**

New Recorder

A new recorder has capabilities of measuring unknown and widely varying levels

BOTH ARE FINEST FOR THE PLASTICS INDUSTRY

ROYLE SPIROD EXTRUDERS

ROYLE TECHNICAL SERVICES

Hundreds of Royle Spirod Extruders are now in operation — and out-producing competitive models — in all of these industries:

BLOWN FILM	FLAT FILM
RIGID SHEET	COMPOUNDING and COLORING
RECLAIMING	
BLOW MOLDING	PIPE
SHAPES and PROFILES	WIRE and CABLE INSULATION

ROYLE
Paterson, N. J.

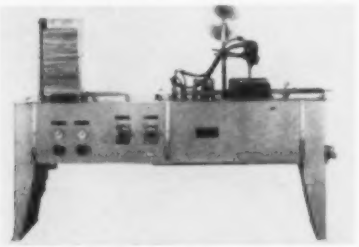
At John Royle, service does not stop with the delivery of a fine extruder. Our policy is to provide field assistance for installation, start-up and any ensuing production problems which may occur.

In addition, users of Royle Extruding Equipment have available to them, at all times, our experienced Engineering Staff for consultation. A laboratory facility for the testing and development of new products and methods — at no charge to the user — is another Royle feature.

JOHN ROYLE & SONS

of potential. Having from 2-5 automatic steps of zero suppression, the zero is automatically shifted to accommodate any signal within a specified range. Accuracy is ¼ of 1% of entire span and a sensitivity of 1/10 of 1% of each span. *Dept. SPE,* **Barber-Colman Co., Wheelco Industrial Instruments Div., Rockford, Ill.**

Spray Coater



A new model spray coater accurately spray coats axial lead components at the rate of 3000 to 10,000 per hour, depending upon the part and coating material, according to the manufacturer. *Dept. SPE,* **Conforming Matrix Corp., 379 Toledo Factories Bldg., Toledo 2, Ohio.**

Planetary Mixer

New vertical mixer of 5-gallon capacity is particularly suitable for pilot plant operations in chemical processing, where contamination between batches of material must be avoided. Ideal for solid propellant fuels or abrasive materials. *Dept. SPE,* **Chem. Mach. Div., Baker Perkins Inc., 1000 Hess, Saginaw, Mich.**

Multi-Point Controller

A new controller provides accurate automatic two-position control for up to ten separate processes. It can also be used as a single point controller, a five-point three-position controller and a manual-balance indicator. *Dept. SPE,* **Thermo-Electric Co., Inc., Saddle Brook, N.J.**

Instruments Measure Press Loads

Two electronic precision instruments safeguard against damage to presses and dies during production runs, according to the manufacturer. Response is instant regardless of press speed, and can be arranged to actuate a warning signal. *Dept. SPE,* **Niagara Machine & Tool Works, 683 Northland Ave., Buffalo 11, N. Y.**

Forming and Slitting Machine

Vacuum forming machine is particularly suited for manufacturing such items as ice cream containers, lids, portion servers, blisters, flower pots, and other items. It provides complete and automatic slitting at speeds of 6 to 10 cycles per minute. *Dept. SPE,* **Comet Industries, 9865 Franklin Ave., Franklin Park, Ill.**

MANUFACTURERS' LITERATURE

Color Matching

A complete line of accessories for coloring instruments is described in a brochure. Complete accessory line enables one to measure colors of a variety of materials. *Dept. SPE,* **Meeco Instruments, 16 Maple St., Summit, N. J.**

Reinforced Plastics

A 32-page illustrated booklet describes resins, reinforcements, and releases used in laminating and casting. Also includes technical data on contact and spray-up molding. *Dept. SPE,* **Allied Resin Products Corp., Hingham Industrial Center, Hingham, Mass.**

Potting, Encapsulating Equipment

Four-page brochure describes production equipment for impregnating, potting, encapsulating, plastics molding, relay drying and filling systems, urethane foaming, vacuum drying, and heat treating. *Dept. SPE,* **Hull Corporation, Hatboro, Pa.**

Blow Molding Resin Guide

Six-page brochure lists injection and blow molding polyethylene resins. Brochure contains tabular data on significant properties. Product data guide on polystyrene resins is also available. *Dept. SPE,* **Rexall Chemical Co., P.O. Box 37, Paramus, N. J.**

Fluorine Plastics

Vinylidene fluoride resin is the subject of a new brochure, containing information on properties and applications. *Dept. SPE,* **Pennsalt Chemicals Corp., 3 Penn Center, Phila. 2, Pa. (Bull VF2R-60).**

Pigments Data

A complete technical brochure covering properties, typical uses and general procedure concerning application of pigments is available from manufacturer. Brochure contains general discussion on properties of pearl pigments, problems of orientation and techniques, and types available. *Dept. SPE,* **Rona Pearl Corp., East 21st St. and East 22nd St., Bayonne, N. J.**

Resins Catalog

Complete line of polycarbonate and phenolic resins, and varnishes and molding powders is described in new resins catalog. Write: *Dept. SPE,* **General Electric Co., Chemical Materials Dept. Pittsfield, Mass.**

Vinyl Stabilizers

Handbook on vinyl stabilizers provides complete data on stabilizing all forms of vinyl products including rigids, flexible vinyls, plastisols and organosols, expanded vinyls, and asbestos tile. *Dept. SPE,* **Ferro Chemical Div., P. O. Box 349, Bedford, Ohio.**

Machining and Forming

Twenty-page booklet gives detailed information on machining, forming, finishing and joining of acrylic sheets and other shapes. *Dept. SPE,* **Cadillac Plastic & Chemical Co., 15111 2nd Ave., Detroit 3, Mich.**

Resins Handling

Engineering techniques used by 7 major manufacturers for bulk handling plastic resins in hopper car quantities is the subject of a new technical booklet. *Dept. SPE,* **Monsanto Chemical Co., Springfield, Mass.**

Paint Binder

New 24-page booklet describes a latex binder for both exterior and interior paints. *Dept. SPE,* **Monsanto Chemical Co., Springfield, Mass.**

Ethers

An elaborate technical data book on ethers has been published. It contains such data as physical properties, solubility data, test methods, shipping data, physiological properties, etc. This unusual publication even contains literature references. *Dept. SPE,* **Union Carbide Chemicals Co., 270 Park Ave., New York 17, N. Y.**

Hydraulic Oils

A technical bulletin gives data and recommended use for 11 straight distilled Circo oils with viscosities ranging from 55 SUS to 140 SUS at 210°F. *Dept. SPE,* **Sun Oil Co., Ind. Prod. Dept., 1608 Walnut St, Phila. 3, Pa.**

Coating Formulations

Thirty-five page brochure describes cellulose acetate for protective coating formulations. Typical uses given. *Dept. SPE,* **Eastman Chemical Products, Inc., Kingsport, Tenn.**

Polyethylene Resins

A 4-page data sheet lists most commonly used polyethylene resins, their main properties, their predominant applications. *Dept. SPE,* **U.S. Industrial Chemicals Co., 99 Park Ave., New York 16, N.Y.**

Polyethylene Applications Guide

Attractive, 4-color catalog gives complete information on present applications and future uses of high density polyethylene. *Dept. SPE,* **Phillips Chemical Co., Bartlesville, Okla.**

*Johnson reel (Denison-Johnson Corp.); Imperial 8 radio (Admiral Corp.); Aqua Hone sharpener (Sun Enterprises, Inc.)

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TECHNICAL MEETINGS CALENDAR

1961 REGIONAL TECHNICAL CONFERENCES (RETECS)

March 14—Plastics Finishing Seminar sponsored by Southern California Section with cooperation of Finishing PAG, Roger Young Auditorium, Los Angeles, Calif. Chairman: Milton T. Schimmel, c/o Decorative Engineering and Supply, Inc., 17000 South Western Ave., Gardena, Calif.

April 4-5—Plastics Injection Molding Workshop sponsored by Pioneer Valley Section with cooperation of Injection Molding PAG, Holy Cross College, Worcester, Mass. Chairman: Roger Johnston, c/o Foster Grant Co., Inc., 289 North Main St., Leominster, Mass.

April 20—Plastics—A New Dimension in Buildings sponsored by Western New England Section with cooperation of Plastics in Buildings PAG, Springfield, Museum of Fine Arts, Springfield, Mass. Chairman: Robert W. Sherman, c/o Union Carbide Plastics Co., 410 Asylum St., Hartford 3, Conn.

May 9—Plastics in the Automotive Industry sponsored by Detroit Section with cooperation of Plastics in the Automotive Industry PAG, Detroit Mich. Co-Chairmen: John A. McPherson, c/o Underground Products Inc., 12801 Inkster St., Livonia, Mich., and John J. Doyle c/o Rohm & Haas Co., 20211 Greenfield St., Detroit 35, Mich.

June 14—Plastics in Packaging—Sheraton Mount Royal Hotel, Montreal, Quebec, Canada. Chairman: Ralph Noble, c/o Canadian Industries, Ltd., P.O. Box 10, Montreal, Quebec, Canada.

September 12—Plastics for Tooling sponsored by Central Indiana Section, Hotel Severin, Indianapolis, Ind. Chairman: Eugene C. Quear, c/o Delco-Remy Division, General Motors Corp., 2401 Columbus Ave., Anderson, Ind.

October 5—Plastics Foams sponsored by Buffalo Section. Section President: William Dunmyer, c/o The Carborundum Co., Building 71-1, Buffalo Ave., Niagara Falls, N. Y.

October 25—Plastics in Major Household Appliances sponsored by Kentuckian Section, Monogram Hall, Appliance Park, Louisville, Ky. Chairman: Ray E. Eshenaur, c/o General Electric Company, AP-5-249, Appliance Park, Louisville, Ky.

November 2-3—Plastics in Packaging and Engineering Exhibition on November 1, 2, 3. RETEC sponsored by North Texas Section and Exhibition by Section with cooperation of Southwestern Division Chapter, Society of Packaging and Handling Engineers, Sheraton-Dallas Hotel, Dallas, Tex. Chairman: Peter W. Kent, 3637 Mid Pines Drive, Dallas 29, Texas.

November 15—Vinyl Plastics in the Household sponsored by New York Section with cooperation of Vinyl Plastics PAG, Statler Hilton Hotel, New York, N.Y. Chairman: Saul Gobstein, c/o Ferro Chemical Co., Box 607, Emerson, N. J.

December 1—Plastics Screw Injection Molding sponsored by Cleveland Section, Cleveland Engineering Society Building, Cleveland, Ohio. Chairman: Edward J. Haskins, c/o Injection Molders Supply Co., 17601 South Miles Road, Cleveland 28, Ohio.

Offers of papers for presentation at these Regional Technical Conferences are invited. Please address offers to RETEC Chairman or Section President.

ANNUAL TECHNICAL CONFERENCES (ANTEC's)

January 30-February 2, 1962—18th ANTEC, Penn-Sheraton Hotel, Pittsburgh, Pa. Sponsored by Pittsburgh Section. General Chairman: John E. Parks, H.P.M. Division, Koehring Co., 512 Empire Building, Pittsburgh 22, Pa.

January 22-25, 1963—19th ANTEC, Ambassador Hotel, Los Angeles, California. Sponsored by Southern California Section. For information write Executive Secretary Thomas A. Bissell, Society of Plastics Engineers, Inc.

January 28-31, 1964—20th ANTEC, Chalfonte-Haddon Hall, Atlantic City, N. J. Sponsored by Philadelphia Section. For information write Executive Secretary Thomas A. Bissell Society of Plastics Engineers, Inc.

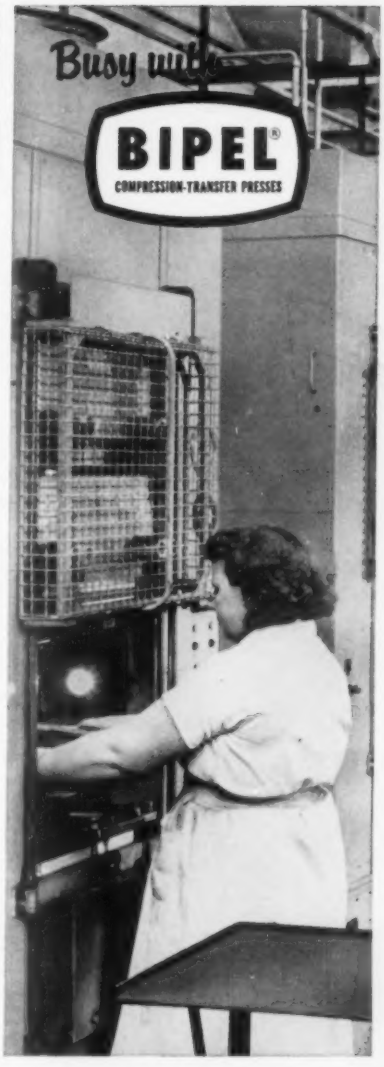
January 18-22, 1965—21st ANTEC, Boston, Mass. Sponsored by Eastern New England Section. For information write Executive Secretary Thomas A. Bissell, Society of Plastics Engineers, Inc.

INTERNATIONAL PLASTICS SHOW

June 21-July 1—International Plastics Exhibition and Convention, Olympia, London, England, Organized by **British Plastics.** Address inquiries to: Interplas '61, Dorset House, Stanford St., London S. E. 1, England.

POLYMER SYMPOSIUM

July 27-August 1, 1961, International Symposium on Macromolecular Chemistry, Montreal, Canada. Address inquiries to: The Organizing Committee International Symposium on Macromolecular Chemistry, P.O. Box 816, Sarnia, Ontario, Canada.



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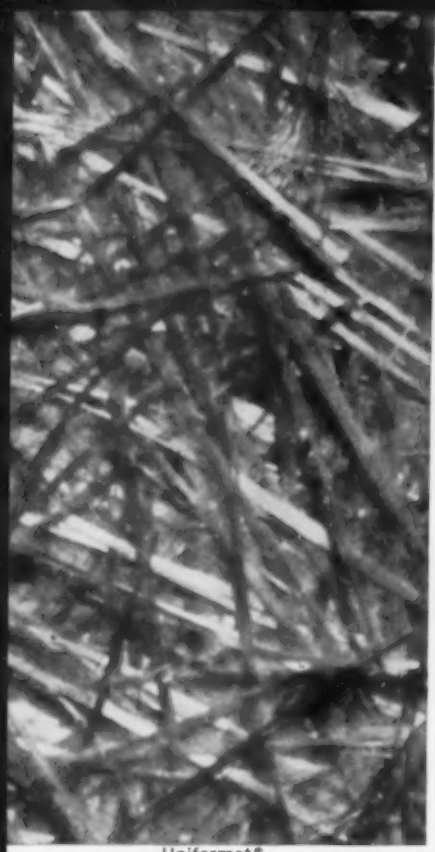

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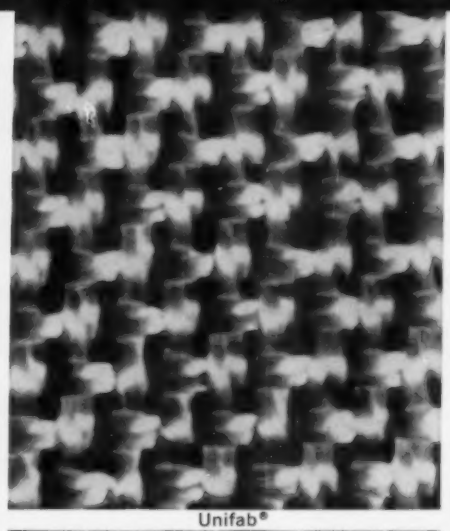

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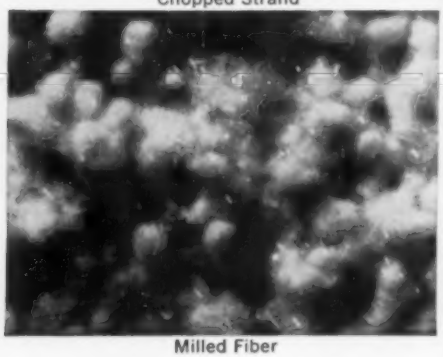
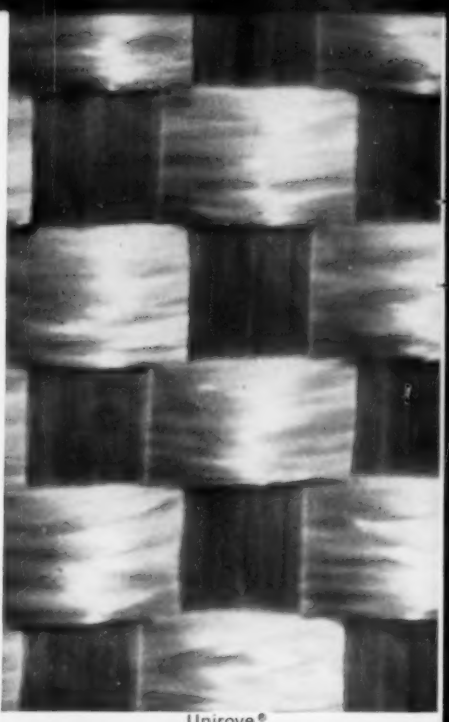


Milled Fiber



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Saul Gobstein, *Chairman, PAG Executive Committee*
(Ferro Chemical)

PAGs Assume Increased Responsibilities in Revised Society Organization

PAG Progress

The revised organization of the Society has given PAGs greater areas of responsibility in the collection and dissemination of technical information. This organization provides the PAGs with an Executive Committee composed of the 7 Regional PAC Advisors and 4 additional members, all of whom have served or are serving as PAG Chairmen. The purpose of this Committee is to perpetuate the dynamic growth of our movement, to advise the PAGs where necessary, and to help stimulate interest in PACs on the Section level.

With the formation of the Technical Program Committee PAGs will have a greater voice in all future ANTEC programs. The PAGs are represented on this Committee by the Chairman of the PAG Executive Committee. The table of organization of the PAGs is as shown in the following chart.

ENGINEERING BOARD

Chairman: James R. Lampman, General Electric Co.
Vice Chairman (for PAG activities):
Carl H. Whitlock, Whitlock Associates

PAG EXECUTIVE COMMITTEE

Chairman: Saul Gobstein, Ferro Chemical Div.

Exec. Comm. (PAG Regional Advisors)
Robert W. Sherman Union Carbide Plastics Co. (Region I)
Joseph R. Grenier Protective Closures Co., Inc. (Region II)
David L. Sahud Radiation Applications, Inc. (Region III)
Byron W. Nelson National Cash Register Co. (Region IV)
Richard A. Jenkins Coast Mfg. & Supply Co. (Region V)
Ross H. Dean Sterling, Inc. (Region VI)
Thomas F. Schaub Furane Plastics Inc. (Region VII)

Members-at-Large: (PAG Chairmen)
Walter A. Gammel, Sr. National Connector Corp.
Thomas E. Hayden Bee Chemical Co.
Armand Winfield DeBell & Richardson
Donald N. Wood Plax Corp.

PAGs and Chairmen
PLASTICS IN BUILDINGS Armand Winfield, DeBell & Richardson
PLASTICS IN ELECTRICAL INSULATION A. F. Zavist, General Electric Co.
EXTRUSION Robert A. Gilden, Enjay Chemical Co., Inc.
REINFORCED PLASTICS Herbert E. Ennis, Brunswick, Balke, Collender Co., Inc.
INJECTION MOLDING Roger B. Staub, Union Carbide Plastics Co.
METAL MOLD DESIGN AND CONSTRUCTION Russell E. Schoeller, Sarcol Foundry and Pattern Corp.
CASTINGS AND PLASTICS TOOLING Edward Ferrari, General Electric Co.
FORMING Donald N. Wood, Plax Corp.
FINISHING Thomas E. Hayden, Bee Chemical Co.
THERMOSETTING MOLDING Ross H. Dean, Sterling, Inc.
VINYL PLASTICS Joseph P. Clancy, Lehigh Chemical Co.
POLYMER STRUCTURE AND PROPERTIES Herman S. Kaufman, Allied Chemical Co.
STANDARDS FOR REPORTING PROPERTIES Kenneth A. Erwin, Marbon Chemical Co.
PLASTICS IN THE AUTOMOTIVE INDUSTRY Travis H. Meister, Ford Motor Co.
BLOW MOLDING William O. Bracken, Hercules Powder Co.
COLORING OF PLASTICS Maret Bacci, Vogt Manufacturing Corp.

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SOCIETY ACTION

Highlights of SPE Progress at 17th ANTEC

Robert D. Forger, *SPE Staff*

ANTEC week was an unusually busy period for those SPE members involved in administration of the varied activities of the Society. Virtually all standing committees met during the period, all PAGs held their Annual Business Meetings, as did the international Society, and Council met twice—for the last meeting of the 1960 Council and first of the 1961 Administration.

The Annual Report, published in the February issue of the Journal, summarizes reports of 1960 Committees, all of which were received by Council at its first ANTEC meeting.

New Organization

Final approval, in the form of adoption of implementing By-Laws, was given the revised organization of the Society at the January 23 Council meeting. This new organization thus became effective with the seating of SPE's 1961 President after the Annual Business Meeting on January 25.

The following Executive Committee members were appointed as Committee Administrators under the SPE Engineering and Administrative Boards by SPE Vice President, Engineering, James R. Lampman, and SPE Vice President, Administration, John Delmonte, Chairmen, respectively, of these two Boards:

Engineering Board

S. H. Greenwood, Administrator

Committees: Technical Information, Inter-Society Relations, Plastics Institute, Publications including Editorial Advisory Board, and Technical Volumes.

C. H. Whitlock, Administrator

Committees: PAGs, Education, Meetings, and Technical Program.

Administrative Board

D. E. Eells, Administrator

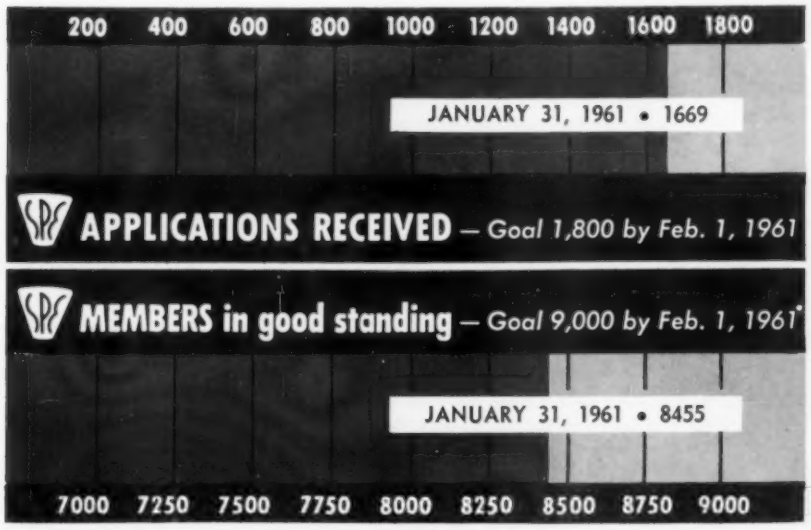
Committees: Finance, Constitution and By-Laws, Nominating including Election Inspectors, and Public Relations.

S. M. Crawford, Administrator

Committees: Membership and Student Membership Subcommittee, Credentials, Sections and Speakers Subcommittee, and New Sections Development.

Constitutional Amendments

Other action in the Constitution and By-Laws area featured Council proposal of two Constitutional amendments. The first outlines action should the Society ever be dissolved and is a requirement of the Internal Revenue Service to obtain SPE proper and desired tax classification. The second provides retention of the two most recent Past Presidents on Council and the Executive Committee for two years instead of one year. All members already will have received complete details on these proposed amendments from the letter mailed in February, as required by the SPE Constitution.



Awards

SPE's first award for technical achievement in plastics science and engineering was established. Consisting of a gold medal and a cash honorarium, this award will recognize "outstanding contributions to plastics science and engineering" by any scientist or engineer in the world. It may, but must not necessarily, be awarded annually and is the technical counterpart of the President's Cup. It is expected that the first award and required lecture will be made at the 1962 ANTEC in Pittsburgh.

For his untiring efforts in developing the Sections Manual of Procedures, and in many other areas, G. Palmer Humphrey was awarded the 1960 President's Cup for "outstanding and meritorious service to the Society."

Sections and Membership

In addition to announcement of final results of the 1960 Membership Contests (see below) a number of proposals directly involving Sections and the individual member were acted upon. These included:

1. Approval of first reading of a By-Law revision altering the rebate structure closely following the formula used by related Societies for more equitable distribution of rebates among Sections.
2. The Section Councilman was made responsible for expediting prompt processing of new member applications by the Section Credentials Committees and Boards of Directors. Two months was established as the maximum time for Section processing of applications.
3. A total of 242 new membership applications were received at ANTEC.

PAGs

At ANTEC, PAGs enjoyed their finest hour to date with total attendance of 1200 at the 16 Annual Business Meetings. Biggest drawing cards were the special programs and panels sponsored by three of the Groups.

The new PAG Executive Committee held its initial meeting and considered a number of ideas and proposals to increase the scope and effectiveness of PAG activities.

Meetings

Considerable action can be expected in this area in 1961 as the new Meetings Committee already has under consideration the following:

1. Selection of the site of 1966 ANTEC
2. Selection of the site of 1967 ANTEC (SPE's Silver Anniversary)
3. Consideration of rules for allocation and limitation of number of 1962 RETECS
4. Consideration of proposed new procedures for awarding future ANTECS
5. Revision of ANTEC Manual of Procedures
6. Possible redesign of ANTEC badge holder

MEMBERSHIP

Final tally for the year ending January 31, indicates that a total of 1669 new membership applications, slightly short of the 1800 goal, were received. At the same date the Society had 8,455 members-in-good-standing, also below the goal of 9000.

The 1960 International Membership Contest was won by the Monterrey Section with a membership increase of 51.7%. Complete results of both this and the Inter-Regional Contest are shown below.

INTERNATIONAL CONTEST

STANDING	SECTION	% INCREASE
1	Monterrey	51.7
2	Florida	35.8
3	Rocky Mountain	30.3
4	Ontario	29.8
5	Quebec	24.6

INTER-REGIONAL CONTEST

REGION	WINNING SECTION	% INCREASE
I	Southeastern New England	15.1
II	Ontario	29.8
III	Baltimore-Washington	10.5
IV	Cleveland	12.6
V	Monterrey	51.7
VI	Toledo	16.5
VII	Rocky Mountain	30.3

■

Edited by
Thomas A. Bissell,
Executive Secretary

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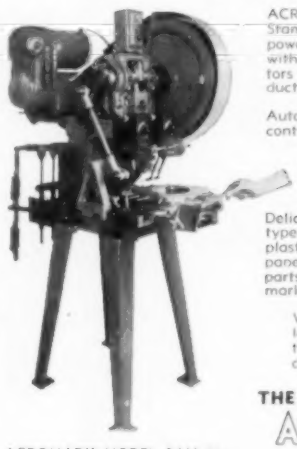

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At Eastman men and machines are ready to help you develop better extrusion and blow molding techniques

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Today, with the fast-developing market for flexible film and the huge potential market for plastic containers, the Tenite Development Laboratory is ready with specialists in all phases of extrusion and blow molding.

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These men and their machines are at your disposal to help you work out problems in the rapidly expanding fields of extrusion and blow molding. To take advantage of this service, call your local Tenite representative, or write directly to EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

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ABOUT MEMBERS

Lunn Laminates, Inc., reinforced plastic molders, has promoted **Roy Berg,** senior project engineer to chief production engineer. He started with Lunn in 1950.

John S. McBride has joined the Fiber Glass area of J. P. Stevens & Co., Inc., as assistant to the technical director, Richard G. Horton. A graduate of Stevens Institute of Technology, Mr. McBride was associated with Owens-Corning Fiberglas Corp. for over nine years. He will be mainly concerned with fabrics for industrial end uses.

James M. Margolis of Chemical Marketing and Research Co. recently described the plastics industry to investors. He presented a paper on "Plastics Growth Centers" before the New York Society of Security Analysts.

J. Walter Guyer is the new Director of Special Projects for Ren Plastics, Inc. Mr. Guyer, formerly Director of Ren's Development Laboratories, holds an M.S. degree in chemistry from Bucknell University.

Spencer Chemical Company has promoted **James Doti** to manager of the technical information and evaluation section and **Glen Tolle** to supervisor of technical services of its Plastics Division. Mr. Doti joined Spencer in 1947 and Mr. Tolle, in 1952.

Enrique Schele, Executive vice president of Thermoplastic Equipment Co., has described the new Andouart Helicolor Wire Coating Machine as the "fastest 3-color helical striping and insulating machine available in the world". The company was recently appointed exclusive agent for the new Andouart unit.

William J. Peacock has been elected vice president of D. A. Campbell & Co., Inc., Cleveland, Ohio. The firm was formerly Ducros & Co., Inc.

Weber Plastics, Inc. has appointed **Richard Ragnow** sales manager, Custom Molding Division. Mr. Ragnow served the company as Technical Representative in Midwestern states.

Jack G. Fuller has become national sales manager for Ankerwerk International and Krauss-Maffei International. Mr. Fuller, taking over the job of expanding the sale of the company's new reciprocating screw plasticizing injection molding machines in the United States, recently resigned from Rexall Drug and Chemical Co.

L. E. Stollenwerck has been named director of public relations, Spencer Chemical Co. Mr. Stollenwerck has been with the company since 1950 as a public relations representative.

Louis P. Deis has been appointed Manufacturing Superintendent for AviSun Corp.'s film and fiber plant in New Castle, Del. Mr. Deis, who holds a B.S. and M.S. in chemical engineering from Massachusetts Institute of Technology, joined American Viscose in 1953 and was Section Leader of the Polyolefin Film Development Laboratories.

Edward T. McBride has joined CIBA Company, Inc. as a technical sales representative in the pigments division. He was formerly associated with Foster-Grant Co., General Tire and Rubber Co., Burgess Pigment Co. and Monsanto Chemical Co.

To direct the operation of the recently formed Plastics Machinery Division, the Producto Machine Co. has named **Sheldon Saslawsky.** A graduate of Rensselaer Polytechnic Institute, Mr. Saslawsky was formerly associated with Auto Vac Co. as Chief Engineer. The new division is introducing its line of blow molding and sheet form equipment to the plastics industry.

Richard G. Adams will head Fiber Glass Research for the Stevens Central Research Laboratories. Mr. Adams holds a B.S. in Chemistry from Brown University, '50, and was with Owens Corning Fiberglas Corp. until 1958. Until his recent appointment, Mr. Adams was engaged in various assignments for Owens including the Chevrolet Corvette reinforced plastic auto body project.

Dr. John J. Bohrer has been elected a Fellow of the New York Academy of Sciences in recognition of his "outstanding work toward the advancement of science." Dr. Bohrer, Director of Research for International Resistance Co., is the author of numerous technical studies on such subjects as copolymerization and organic semiconductors.

Maurice F. Malone, recently elected Secretary of SPE, has been appointed to the newly created position of sales supervisor, industrial products, for the Canadian Resins Division of Shawinigan Chemicals, Ltd. He is a graduate of Loyola College and McGill University and has been with the company since 1952.

Edward Tarnell was named president of Roger Williams Technical & Economic Services, Inc. Formerly an executive vice president, Mr. Tarnell, a graduate of the Polytechnic Institute of Brooklyn, has been with the firm since 1952. **Roger Williams, Jr.,** former president, became chairman of the board of directors.

James E. FitzGerald became manufacturing services manager for Brunswick Corp.'s international division. Prior to his appointment to the newly created position, Mr. FitzGerald had been plant manager of Brunswick's Marion, Va., defense operations. He has been with the firm since 1940. A graduate of the University of Michigan, he has been honored three times for distinguished community service, including the Silver Beaver Award, the highest honor in Scouting.

Robert E. Reynolds has joined G. Felsenthal & Sons, Inc., as a technical sales representative of the custom molding and fabricating division in the Chicago and surrounding states areas.

Robert Lambert, Jr., will head the recently created Custom Molding Division of Loma Industries, Inc. It will be one of the few plants employing all forms of plastic production. **E. E. Busby** will be Chief of Engineering and Development, assisting Mr. Lambert.

Kansas City

Plastics in Automotive Use

William M. Bower (The Bendix Corp.)

Mr. J. R. Forrester of the Engineering and Research Staff, Ford Motor Co., presented a paper entitled "Automotive Uses and Requirements of Plastics" to the Kansas City Section on Monday, January 16. Thirty-six members heard Mr. Forrester discuss the material requirements for automotive materials under various criteria of environment, application requirements and total cost, including material and labor. The number of plastic parts per car was covered and the future use projected. It was stated that the greatest need was a material easily fabricated, with a high modulus up to 200°F and also with a low coefficient of expansion.

Cleveland

Morse Talk

A Cleveland RETEC Preview

A. R. Morse of Injection Molders Supply Co., addressed the Cleveland Section of SPE Monday, February 20, 1961, on the topic of "Screw Injection Machines."

The meeting was held at Pesano's Restaurant. Mr. Morse reported upon a recent visit to eleven injection machinery manufacturing concerns in Germany, Switzerland and England and discussed the pros and cons of screw injection which has swept the European molding industry.

The talk was a preview of the Cleveland SPE (RETEC) Regional Technical Conference to be held in November, 1961. Screw Injection Machinery will be discussed by the European suppliers.

Plastics in Germany and Russia

E. K. McCLELLAN

(Eastman Chemical Products, Inc.)

The November meeting of the S.P.E. Cleveland Section was held Monday, November 21, at Pesano's Restaurant, Cleveland, Ohio. There were 103 members and guests on hand to hear a talk by Mr. Michael Ladney, President of Detroit Plastic Molding Company, speak on "Plastics in Germany and Russia". Mr. Ladney's talk was augmented by molded articles from Europe and a colored motion picture film taken during his trip.

The Thomas E. Orr awards were presented to a student of Case Institute of Technology and a student of the University of Akron who were thought by their professors to have shown outstanding work in the field of plastic technology. Mr. Thomas E. Orr was one of the founders of the Cleveland Section and was prominent for years in the National Chapter. The award, in his memory, was initiated in 1953.

Akron

Akron Section Celebrates Second Anniversary

George Reesman (Rubbermaid, Inc.)

Two excellent speakers were on hand to help the Akron Section celebrate its Second Anniversary in January. Mr. Frank W. Adkins, Jr., of the B. F. Goodrich Co. spoke on "Modern Day Adhesives." The four broad classifications covered, water based, solvent based, thermoplastic and thermosetting, are all making inroads into the auto and construction industries.

Mr. Meryle Sanger of the General Tire & Rubber Co. spoke on "Urethane Plastic Foams—A Technical Achievement." Mr. Sanger pointed out the improved properties of polyether foams over the first polyester foams. Mr. Sanger anticipates a continuing climb in usage of foams—particularly in the furniture industry.

Golden Gate

Blow Molding

Meyer R. Rabin (Transparent Products Corp.)

Fifty-two members and guests of the Golden Gate Section met January 10, 1961 for the regular monthly meeting.

President Brant Newsom, presiding, called upon Scotty Allen, Secretary, who explained the Section's participation in a course on Plastics to be held at San Francisco State College.

Mr. Newsom introduced the guest speaker, Mr. Robert Clark of Hercules Powder Co., Wilmington, Del., who spoke about new developments in blow molding. In 1958, he pointed out, there were about ten companies making blow molded articles; in 1960, there were over 250, demonstrating the tremendous growth in this field. Whereas blow molded bottles have been the prime item, there is a growing trend in the toy and automotive industries for other blow molded items. Mr. Clark, in summing up, mentioned that containers have been blow molded in five colors, and there is a machine capable of blow molding a container in 250-gal size.

SECTION NEWS

Ontario

Ontario Meeting Features Story of Cycolac

Harold Shure (Naugatuck Chemicals)

A colored film on Cycolac, the tough, rigid, ABS plastics manufactured by the Marbon Chemical Division of Borg-Warner, highlighted the January meeting of the Ontario Section in Toronto.

The film was introduced by Walter Kosy, Detroit representative for Marbon Chemicals.

In his remarks introducing the color film, Mr. Kosy said that Cycolac initially got its start about five years ago as a high impact material. It has high impact strength at low temperatures. In many instances it is replacing die casting in the automotive industry at savings as high as 25%. Because it has no plasticizer, paint doesn't attack the plastics and cause warpage. Also, nitrate and acrylic lacquer can be used without a primer when a part is to be painted.

Western New England

Blow Molding Discussion Draws Record Attendance

R. W. Sherman (Union Carbide Plastics Co.)

The January meeting of the Western New England Section of SPE proved that once again blow molding is one of the most topical subjects that can be covered by our Society. Attendance was 40% above our average for the year!

Technical Chairman of the evening was Mr. Grant Brown of Plax Corp. who briefly discussed the future and past of blow molding. Our speaker, Mr. Herbert Samuels of Union Carbide Plastics Co., combined a very interesting talk with slides and motion pictures showing the four major blow molding processes in actual operation.

The Section also enjoyed the recent holiday season with a highly successful dinner and dance party on December 2. The party, chaired by

WHAT'S NEWS IN ENJAY TECHNICAL SERVICE

Enjay helps reduce cost of 90°C vinyl wire insulation...

An important part of Enjay Technical Service is developing useful new products that reduce costs, yet maintain performance. Ditridecyl phthalate for use in plasticizing vinyl wire insulation is a good example of this research activity. By tests, such as the oven aging shown above, Enjay was able to prove that DTDP, made from Enjay tridecyl alcohol, performs as an efficient, non-volatile plasticizer for 90°C wire — yet reduces plasticizer cost. Test results, at right, show that the insulation exceeds the U.L. Specifications.

Enjay research facilities and technical skills are available to customers in the vinyl wire, film and sheeting industries.

If you would like to receive a free copy of our new Technical Bulletin No. 20 on Enjay oxo alcohol for plasticizers, write to 15 West 51st Street, New York 19, N. Y.

TEST RESULTS: 7 DAYS @ 121°C

	U.L. Specification Minimum	DTDP Plasticizer
Elongation	65% retention	100% retention
Tensile Strength	65% retention	101% retention
Dielectric Strength	50% retention	127% retention
Insulation Resistance*	.01 megohm based on 1000 ft.	0.36 megohm based on 1000 ft.

* 1 day and 7 days @ 113°C.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY

PETROCHEMICALS

Armand Winfield, was unique in the annals of SPE parties in that it had a gambling casino using scrip.

Southern California

Implex to Be Discussed

John A. Stahmann
(Rocketdyne Div., North American Aviation Co.)

"Implex—Its Uses and Markets" will be the subject of a talk by Mr. Robert L. Gardner, Rohm & Haas Co., March 2, 1961. Members wishing further information, contact Mr. Sam Silberkraus, Program Chairman, c/o Riverdale Plastics & Chemical Corp., 9014 Lindblade St., Culver City, Calif.

St. Louis

Flame Retardant Plasticizers

R. H. Kochrmann (International Shoe Co.)

The January meeting of the St. Louis Section of the SPE was held at Holiday Inn, South, on January 16, 1961 with 41 members and guests present. Following dinner, a discussion was led by Mr. W. F. Waychoff and Mr. D. H. Bechtold, Monsanto Chemical Co., Organic Chemicals Division on "Flame Retardant Plasticizers and Modifiers for Vinyls, Epoxies, Polyesters, Polyethylene and Phenolics."

The next meeting will be held on February 20, at Holiday Inn, and will feature a speaker in the labor relations field.

On December 19, 1960, 35 members and guests of the St. Louis Section of the SPE gathered at the Holiday Inn, South, for the annual Christmas party. Following dinner, Bank Night at Monte Carlo was run sponsored by Cadillac Plastics.

New York

New York Section RETEC Committee Appointed

The following members have accepted appointments on the RETEC Committee:

Saul Gobstein, Ferro Chemical Div., Co-chairman
Roy L. Kern, Thompson Chemical Co., Co-chairman
Irwin I. Podell, Irwin I. Podell, Inc., Program chairman
Walter Schalk, Monsanto Chemical Co., House Chairman
Leonard Nass, Advance Solvents & Chemical Co., Membership Chairman
Alva E. Whitney, Goodyear Tire & Rubber Co., Printing Chairman
Michael Sagesse, J. P. Frank Chemical Co., Publicity Chairman
Melvin M. Gerson, Sandoz, Inc., Registration Chairman
Robert Braddicks, Kentile, Inc., Treasurer

The committee has already met and the Statler Hilton Hotel has been selected for the RETEC. The Section anticipates a stimulating conference and a record turn-out!

Central New York

Plastic Foam Applications Discussed

J. R. Lampman (General Electric Co.)

An interesting Central New York Section meeting featured Mr. B. A. Geisert of Dow Chemical Co., Midland, Mich. Mr. Geisert discussed three types of plastic foams and typical applications for each type. He stressed the importance of matching properties to the applications and cited several instances of misapplication of these materials.

His talk was illustrated with a number of excellent slides. The many questions raised by the members indicated the tremendous interest generated. It was generally felt that Mr. Geisert had provided us with one of our better programs of the year.

A Membership Drive was announced by Membership Chairman, Dan Mackessy. The contest closes in May and the prediction was made that our membership would be increased by at least 15 persons as a result of this drive. Our next meeting will be held February 9th. Subject of vacuum metallizing.

Connecticut

Latest Techniques in Injection Molding of Polyolefins

Kenneth G. Clarke
(E. I. du Pont de Nemours & Co., Inc.)

The plastic industry's high level of interest in high density polyethylene and related polyolefins was evident at the January meeting of the Connecticut Chapter. The largest turnout in history heard Mr. Albert Spaak of the W. R. Grace Co. discuss the latest techniques in injection molding of polyolefins.

Mr. Spaak covered briefly the history of high density polyethylene, techniques of manufacture, test methods and types available before getting into the details of several successful new techniques. The greatest molding problems to date with these polyolefins have been (1) overcoming warpage and (2) obtaining high impact strength. Techniques which have proven effective in helping to solve these problems include: multiple gating, hot runner molding, flash gating, valve gating, and use of copper alloy plated molds.

Newark

Polymer Structure

R. E. Christensen (Union Carbide Plastics Co.)

The Newark section met at the Military Park Hotel on January 11, 1961. Program Chairman George Reed announced the appointment of Bob Gilden as his assistant. Their first program was very successful, provoking much discussion and thought on how to relate fabrication behavior to polymer structure.

Dr. Herman Kaufman of Allied Chemical Co., Morristown, N. J., who is chairman of the Professional Activities Group on Polymer Structures and Properties, SPE International was the first speaker. He presented a very lucid and practical short course on the polymer factors affecting properties and how fabrication affects these factors. Included were: 1) molecular weight and molecular weight distribution; 2) morphological factors, including degree of crystallinity, orientation, and spherullite size. Dr. Kaufman demonstrated how fabrication operations can affect these factors and, in turn, affect the properties or performance of the end piece.

The second speaker was Dr. Charles Williamson of Enjay Labs, Linden, N. J., who spoke on "Polymer Properties in Polyolefin Injection Molding." Dr. Williamson discussed the range of polyolefins commercially available, including low and high density polyethylene and polypropylene, in relation to how their basic structural nature affects injection molding.

Miami Valley

Color, at Miami Valley

Roger A. Houston
(Recto Molded Products, Inc.)

Forty members of the Miami Valley Section enjoyed a carefully prepared talk by Roy O. Hill of Tennessee-Eastman's Kingsport plant on "Color and Polyethylene Color Concentrates," on January 5th.

(Continued on page 301)

PLASTICS AROUND THE WORLD

This month's column is possible through the contributions of these abstracters:
Walter A. Gammel, Sr. (ASTM Bulletin)
J. P. Harrington (Rubber Age)
Hans Mayer (Industries des Plastiques Modernes)

United States

RUBBER AGE

NOVEMBER 1960

The Role of Carbon Black in the Thermal Oxidation of Polyolefins—pp 279-283

According to the authors, W. L. Hawkins, M. A. Worthington, and F. H. Winslow, carbon black is a mild inhibitor of the thermal oxidation of polyolefins, being particularly effective at temperatures below the melting range of the polymer. This inhibition may be increased by heating the carbon black in the presence of oxygen or sulfur. Synergistic effects can result in a marked reduction of thermal oxidation when carbon black is added to polyolefins stabilized with certain sulfur compounds. However, with many antioxidants (such as secondary amines and alkylated phenols) the addition of carbon black reduces the effectiveness of the antioxidant.

ASTM BULLETIN

DECEMBER 1960

Blow Molding New Subject for Plastics Committee—22 pages

Committee D-20 activities have been expanded to include preparation of standards on plastic shapes and products. New activities being balloted on by the committee include: Method for coefficient of friction, Method for particle size (sieve analysis), Recommend Practice for: Resistance to Fungi, Injection molding of polystyrene, Transfer Molding of thermosetting materials, Sampling, Specification for: Styrene-Butadiene molding and extrusion compounds, Rigid PVC sheet, tooling plastic casting compounds.

France

INDUSTRIES DES PLASTIQUES MODERNES

NOVEMBER 1960

The Lacquering of Plastics

In certain cases, the application of a lacquer finish to a plastic surface is essential. The author, C. F. Spiess, discusses the problem of finding the proper materials that will give the lacquered molding the desired appearance and qualities without reacting as a solvent on the raw materials originally used in the molding process. He also points out that the re-use of lacquered parts (thermoplastics) can adversely affect the molding process, using such reclaimed materials.

A Light Measuring Process for the Determination of the Structure of Copolymers

H. Benoit and M. Leng, the authors of this article, discuss the structure of a copolymer as determined by placing the material in solvents of various indexes of refraction. By measuring with light the molecular weight can be determined, corresponding to the different monomer types, as well as a parameter which characterizes the heterogeneity of the copolymer.

Polyethyleneglycol Terephthalate—pp 888-893

Part three of a series.

This film has many new uses, some of them potential due to the present lack of a simple, rapid method for heat sealing and the high price of the film. In packaging applications: the film alone; laminates with polyethylenes; with PVC; and others result in a combination of the best physical characteristics of both films. Fresh foods packed in polyester films may be sterilized, roasted or boiled without removing the packaging. Window packages using polyester films may now be applied even to products having sharp points. For decoration in automobiles and on book covers metallized, embossed polyester laminated to other materials combines high wear resistance and strength with extreme brilliance, good looks and flexibility of design. Printed films are laminated also to such substrates as wood, leather and paper for use as wall panels, table tops, shoes and so on. Laminates with thin films of metal can be sliced into narrow ribbons and incorporated for effect into textiles.

OCTOBER 1960

Plastic Sacks—pp 960-965

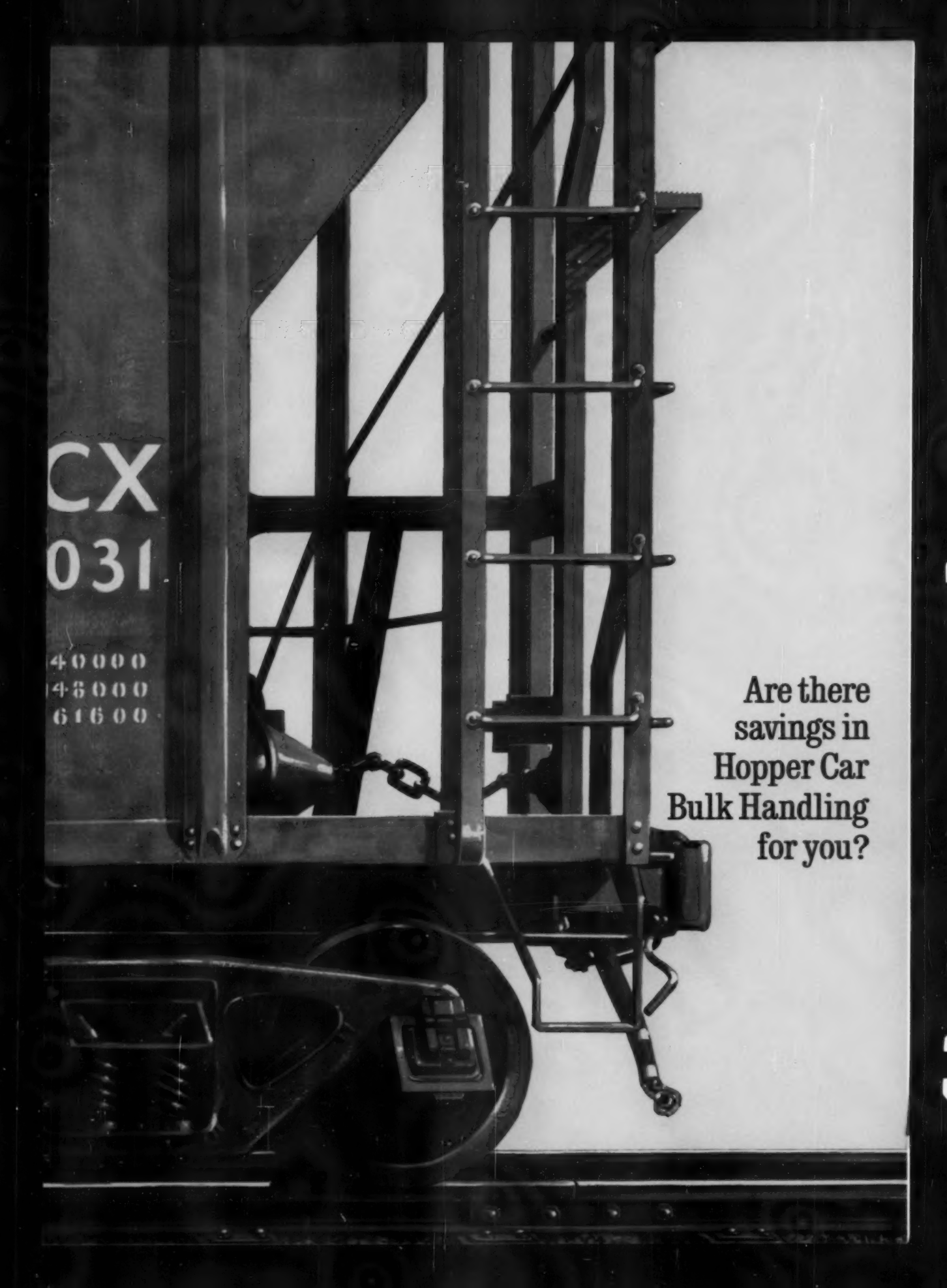
Sacks made of PVC or polyethylene are beginning to assume importance for bulk packaging. In spite of the serious cost differential between the new materials and such packaging as multiwall bags of coated papers, physical properties can be outstanding and are leading to further development and cost economies. A poll taken among persons who have received fertilizers in plastic sacks provided the following answers:

33% said the sacks could now be stored in the open; 90% said plastic sacks were advantageous; 67% said the product kept better in plastic; 60% said they reused the bags around the farm; 30% said the package influenced their choice of brand; 80% said if they could, they would buy all their fertilizer in plastic; 10% noted the higher price but said the advantages outweighed it. The Italian market prefers PVC for sacks, believing it to be stronger and to have surer sealing properties in heavy gauges. Two companies are currently producing sacks in .008 to .012 gauges from calendered sheet and extruded blown tubing.

Polyethyleneglycol Terephthalate—pp 970-978

Part Four — Use of PETP films.

PETP films exhibit excellent electrical properties and are used in condensers, motors, capacitors, as cable insulation, in dry batteries, in loudspeaker cones and so on. They are used as conveyor belting in the food industry. They are coated with adhesives, used as backing for magnetic tape, for drawings and architects' plans, as photographic film, to cover greenhouses, shot into space for communication satellites, and for small boat sails. A worldwide list of trade names, manufacturers and descriptions is included.



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HOPPER CAR BULK HANDLING has enabled many plastics users to reduce their material costs. They have eliminated loss from damage and contamination due to numerous in-plant handling operations. They have simplified inventory through product standardization. Their warehousing is more compact and efficient. They have been able to save on time and labor needed for conventional materials handling systems. All of this is in addition to the current bulk discount.

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Monsanto Chemical Company, Plastics Division, Springfield 2, Mass.

MONSANTO

Monsanto

Mineral Pigments for Coloring Plastics—pp 943-950

Coloring materials can affect the life, mechanical, electrical and chemical properties, and processing characteristics as well as appearance of plastics. Mineral pigments may be oxides or metallic salts. Efflorescence, migration and exhudation, manifestations of solubility of the pigments in binders and of their concentration must be carefully considered in formulations. Stability towards heat, stability to light and reactivity are other areas which govern pigment choice in particular applications. Brief explanations are made of pigmentation required and its incorporation in the following materials: phenolics, urea and melamine, polyethylene, polypropylene, fluorinated resins; vinyls, polystyrene, cellulosics, acrylics, polyamides and polyesters. Tables provide physical properties of common whites, blacks, yellows, oranges, reds, blues and greens.

An Example of Lining a Reinforced Concrete Conduit With PVC—pp 951-956

Fully illustrated description of treatment to 2500 meters of a 1.8 meter diameter aqueduct which was constructed by laying 5 meter sections in a trench and backfilling. External hydrostatic pressure which varied from 1 to 4 atmospheres was compensated for by using pipe in two thicknesses. A 1500 meter length developed faults at the joints because of abnormal thermal stresses during construction. Mechanical strength was not reduced appreciably, but the piping could not be expected to provide the expected service life.

It was decided to line the conduit with PVC sheets since they would not lessen the diameter (as would reinforced gunite) and since the plastic could be relied upon to change dimension as the concrete required. Furthermore, the work could proceed in the depths of winter. The lining was applied in 4 sheets 25 meters long and 1.5 meters wide, the upper three 1.1 mm thick and the lowest 1.5 mm thick. The PVC was stabilized for sufficient flexibility at the working temperature of 17-18 C and for long life. The tube was smoothed with plaster, and primed. Adhesive was then applied to the clean, dry, primed surface and to the plastic. The sheets were applied while still tacky and smoothed and tamped on with wooden tools. Edges were overlapped and subsequently hot air welded to make the joints impermeable. Finally, a ribbon 20 mm wide was placed over each joint according to the procedure described. Inspection after five months of service proved that the coating was performing perfectly.

Polyester Resins in Sheets and Rods—pp 984-986

A complete description of a small factory for producing sheets and rods for making buttons Catalyzed, colored resins are handled in various ways to give novel decorative effects.

Meeting Note

A conference on Education and Training in the Plastics Industry has been scheduled for June 19 and 20, 1961 in London. The dates of this conference were specifically arranged to also permit attendance of the International Plastics Exhibition at Olympia, June 21 to July 1, 1961.

SECTION NEWS (Cont.)

Upper Midwest

Finishing Night

Charles M. Smith (Donaldson Co., Inc.)

It was somewhat gratifying to once again resume our technical meetings after all of the Holiday parties, celebrations, etc. The Upper Midwest Section kicked off the new year with a very interesting and informative lecture on plastic finishing. Mr. Arthur N. Skeels, Vice President, Admiral Coated Products, Inc. discussed "Hot Stamping and Foil Decorating". A second lecture by Mr. R. A. Tiley of American Cyanamid Company was on "Decorating Thermosets".

Mr. Skeels covered new developments in the hot stamping and foil decorating field, including such problems as poor sharpness and detail, excessive leaf flaking, poor adhesion, color bleed or smear, etc.

Mr. Tiley's subject was "Decorating Thermosets" during the molding operation. He supplemented his lecture with many interesting samples of work done both here and abroad. Both lectures were exceptionally good and were heard by a good turnout of members.

Pioneer Valley

Blow Molding Linear Polyethylene

Roger Johnston (Foster-Grant Co., Inc.)

High spot of the January meeting was a talk by Mr. B. J. Morgan of Phillips Chemical Co., who told of his experiences with an injection molding machine converted for blow molding with a hot runner system between the platens and regular extrusion blow molding.

He stressed the importance of the die; pointed out that temperature control with thermometer in the metal was better than in the stock, and explained that in the design of the head, streamline flow is the most important item. A choke ring builds back pressure to reduce weld lines. However a polished surface is no good, and one too rough shows on the items. A land at the heated tip is very useful and a bleed hole at the rear of the pin or mandrel helps color changes.

The injection molding workshop to be held on April 4 and 5 at the Holy Cross College, Worcester, should provide all those directly associated with the details of injection molding with information which can be of direct help. For further details, contact your reporter at Foster-Grant Co., Inc., 289 North Main Street, Leominster, Mass.

Philadelphia

Styling, Decorating and Post Finishing

George R. DeHoff
(E. I. du Pont de Nemours & Co., Inc.)

The January meeting of the Philadelphia Section considered the problems of Styling, Decorating and Finishing with Mr. R. E. Dawson, a consultant specializing in design and styling and Mr. A. N. Skeels on hand to lead the discussion. Mr. Dawson, who is from Huntington Valley, Pa., spoke of the designers' contribution to styling, and provided a picture of the problems of styling and good design concepts. Color slides were shown. A high spot was a view of the acrylic room of his studio indicating the functional use of unusual styling.

Mr. Kees' talk dealt with decorating and post finishing of plastics, primarily blown containers. He pointed out the need to consider the finishing requirements in the early stages of styling an article.

Both speakers were introduced by Chairman Dave Thornburg.

Employment & Service Guide

POSITIONS OPEN

APPLICATIONS ENGINEER

Degree in Chemical Engineering or Chemistry required. Prefer three years' experience in thermosetting and thermoplastic molding techniques and materials; plus, experience or interest in polyester and epoxy lay-up work, low cost plastic tooling, purchased laminates, and application of thermosetting resins. Work to include engineering development, consultation, in-plant manufacturing applications, and specification writing. Liberal Company benefits. Relocation expenses paid. Send resume and salary requirements to: Mr. J. F. Caldwell, Dept. 373, Westinghouse-Baltimore, P. O. Box 746, Baltimore 3, Maryland.

MOLDING POWDER SALESMEN

Compounder and distributor of Polystyrene and Polyethylene requires experienced salesmen with following in Eastern and Midwest territories. Salary and commission, five figure earning potential. Box No. 179, SPE JOURNAL, 65 Prospect Street, Stamford, Conn.

PLASTICS ENGINEERS

Immediate openings in our new Research and Technical Service Center for Engineers familiar with polymer evaluation. We require a Bachelor's Degree and 3 to 10 years experience in plastics processing, physical testing, and/or customer service, particularly in polyolefins and polystyrene. Employment will offer challenging opportunities in applications research, technical service and resin investigation. Location in pleasant suburban Northern New Jersey. Please send detailed resume with salary history and requirements. All replies held in strictest confidence.

Reply to:
REXALL CHEMICAL COMPANY
Dept. KK
P.O. Box 37
Paramus, New Jersey

PLASTICS ENGINEER

Experienced in injection and compression to take full responsibility for engineering and estimating departments. Salary open. Reply to David Rome, Olympic Plastics Co., Inc., 3471 So. La Cienega Blvd., Los Angeles 16, Calif.

TECHNICAL SERVICE

NYC sales office of a leading manufacturer of extrusion machinery seeks a Technical Service Man to provide Customer Service from the desk and in the field on a national basis. Good knowledge of plastic extrusion, equipment maintenance and some German is required to make this position a challenging opportunity in technical service.

All replies held in strictest confidence. Please send brief resume with salary requirements to Box No. 198, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

PLASTICS DEVELOPMENT ENGINEER

We have an attractive opening in our New Product Development Dept. for an engineer or chemist to work on fabrication techniques for new thermoplastics. B.S. minimum, 3-10 years broad experience in fabrication of plastics, especially extrusion. Send resume in confidence to Dr. David M. Clark, Director of Technical Recruiting, W. R. Grace & Co., Research Division, Clarksville, Md.

PRODUCT DEVELOPMENT ENGINEER

A leading converter of plastic film and sheeting has position available in its Development Division. Must be an "idea man" for the development of new products drawing from past experience and from laboratory findings of chemical suppliers. Position requires imagination and initiative and good background of experience and chemical education in the PVC industry. Send resume to Box No. 186, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

Quality Control Engineers

for THE GENERAL TIRE

NEW ENGLAND and MIDWEST LOCATIONS

THE ASSIGNMENT: To supervise quality engineering section, plan projects for quality improvement, investigate and experiment to find causes for quality losses and take corrective action to improve quality conditions where necessary.

THE QUALIFICATIONS: A minimum of 2-4 years in quality control, preferably in a plastics, chemical or textile operation, involving production, technical service or product development. BS in engineering or chemistry preferred.

This is a permanent position created by our continued expansion. Full benefit program and relocation. All inquiries will be answered. Write in confidence to William D. Plant, Jr., Central Personnel.

THE GENERAL TIRE & RUBBER COMPANY

AKRON 9, OHIO

SALES REPRESENTATIVE

Representative for the sale of injection molding machines and auxiliary equipment wanted in the West, South, and Canada.

Reply to: Acme Machinery & Mfg. Co., Inc., 500 Saw Mill River Road, Yonkers, New York.

PLASTICS APPLICATION ENGINEER

Development and technical service on new applications of injection molded Delrin, Nylon, Teflon, polypropylene and styrene parts for mechanical applications. Well-known company with new custom-molding affiliate will pay above-average salary to engineer with ability and initiative. Suburban N. Y. location. Reply Box No. 189, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

ENGINEER—MECHANICAL

M.E. or equivalent wanted for medium size poly Extruder, Flexographic Printer and Converter. Excellent opportunity for experienced engineer to assume responsibility for manufacturing methods, special machine design, quality control, maintenance and repair. Salary and bonus commensurate with ability. Modern plant located in Mass. Send complete resume and salary requirements to Box 195, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

POSITIONS WANTED

SALES PLANNING, PROMOTION, PERFORMANCE

Find out how this chemical engineer's creative approach to marketing problems can help you sell more plastics materials, equipment, or products. Whether your problem concerns a new product or an old one, he can help you. Write Box 175, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

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B.S. Twenty years successful and diversified experience in resins, plastics, adhesives, coatings, fire retardants, impregnation technics, paper, oil filters. Name your product—will develop or improve it. Age 43. Box No. 172, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

PLASTICS ENGINEER

Twelve years experience in Research, and Experimental Engineering. Laboratory and Design experience in the fields of Compression Molding, Laminates, F.R.P., Electronic Component Potting and Adhesives. U.K. Education and training; Four years employment in Canadian Plastics Industry. Interested in position in San Francisco area. Box No. 187, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

SALES, PRODUCT MANAGER

Extensive experience in technical sales and service of polyethylene, polystyrene, nylon in molding and extrusion, and phenolic in molding. More recently in product and marketing management of polyethylene. Seeking position in middle management in sales or product management in the East, preferably in New England. Box No. 180, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

ADMINISTRATIVE PLASTICS ENGINEER

Desires position in plastics—production, process engineering. Customer Service or management. 19 years experience—processing, R&D, Mold & Machine Design, Customer Service & Administration. Well informed on all types of fabrication, thermoplastics & thermosetting materials. Considerable drive. Age 42. Married, family. Will relocate and travel. Resume upon request, interview preferred. Box No. 196, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

IS IT TRUE

that the South and Southwest, with its present industrial growth does not have need for and cannot afford a Sales Engineer-Consultant, who is specializing in Thermoplastics? I believe not, and would therefore like to contact party interested in mutually benefiting each other.

I am 34, have 15 years experience which started as a machine operator, progressed through estimating, engineering, sales, and consulting, to my present position as manager of a small Engineering Consulting firm in one of the largest molding areas in the country. Box No. 197, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

SALES AND MARKETING MANAGER

18 years experience. Heavy in Plastics and Chemicals. Capable of assuming full responsibility for sales, sales training, product management, policy planning, advertising and sales promotion, new product development, customer service and distribution. Excellent references. Box No. 199, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

PLASTICS, RUBBER—ELECTRONICS

With government (military) agency since graduation, B.Ch.E. 1942. Development, applications, testing, specifications. Collaborate with electronic, electro-mechanical engineers: ground equipment, some communication space-satellites. Laboratory, 10 years. Supervisory experience in mold design, compression, transfer, injection molding; rubber compounding, some resin-filler compounding. Age 46; family. Minimum salary $11,500. Resume available. Box No. 193. SPE JOURNAL, 65 Prospect St., Stamford, Conn.

PLASTICS, METALS, PRINTED-CIRCUITS

Both Management and Technical experience in Prototype research, development and limited production for Electronic, Structural and Aerospace Projects. Very heavy experience in Plastics Materials and Processes. Proposal preparation, fabrication specifications and Technical Consultation. Age 32, happy to relocate and travel. Resume available. Box No. 191, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

PLASTICS CONSULTING ENGINEER

25 years diversified experience in all phases of plastics including injection, compression, transfer, mold design and making, low pressure laminates, plastic tooling, setting up plants in blow molding and designing efficient cross-heads for quality production. Consultation and guidance on all your plastics problems. Resume furnished. Box No. 194, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

ADMINISTRATIVE EXECUTIVE

Age 34, 11 years varied experience in extrusion and fabrication thermoplastics. Responsible for purchasing, sales, estimating, administration. Extensive travelling both foreign and domestic for customer relationship, trouble shooting. Seeking challenging position with growth Co. Reply Box No. 192, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

CLASSIFIED RATES

"Position Open" and "Position Wanted"—$12.50 per column inch, 2¼ inches wide. (35 characters per line; 7 lines per inch). Minimum charge: $12.50. "Products and Services"—$20.00 per inch. Minimum charge: $20.00.

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Last day for inserting ads is the first day of the month preceding date of publication. ***Employers please note: The SPE Journal does not have resumes on file. These must be requested from the applicant.***

PLASTICS ENGINEER—ADMINISTRATOR

Twelve years experience in plastics, six in R&D administration. Considerable extrusion experience, particularly polyolefin, polystyrene polymers. Good knowledge of Injection Molding and Film Orientation. Some blow molding experience. Strong background process, product and equipment development. Desire responsible, challenging position with good growth potential. Location—mid-Atlantic area. Salary lower teens. Box 190, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

PLASTICS TECHNOLOGIST

English student, aged 21, taking a Degree qualification in Polmyer Science (A.P.I.) in June would like to obtain a position with a U.S. plastics company on leaving college this summer. Main objectives are the gaining of practical experience of U.S. plastics techniques and a desire to travel. Box No. 188, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

PLASTICS DEVELOPMENT ENGINEER

Chemical engineer, B.Ch.E., with five years experience in process and applications development of plastics, rubber and liquid and solid propellants, desires challenging research or development position. Also has experience in technical writing. Complete resume on request. Box No. 200, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

FILM, WIRE EXPERIENCE

Thirteen years plastics engineering experience; 5 years each film and wire extrusion. Includes production engineering, process and product development, equipment design, troubleshooting, cost reduction, supervision. M. Chem. Eng. wants responsible opportunity requiring solid background, creative thinking. Box No. 201, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

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CONTRACT WORK WANTED

CUSTOM GRINDING . . .
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Polyethylene, Polypropylene, Polystyrene, other thermoplastic materials. Film and sheeting scrap, lumps, filament waste, etc. Also air separation of sweepings & other contaminated molding powders. Equipment includes Sprout-Waldron Pelletizer, Cumberland Grinders, Air Separators. Private RR siding.

PLASTICS RECLAIMING CORP.
Tomkins Tidewater Terminal, South Kearny, N. J. Mitchell 3-4145

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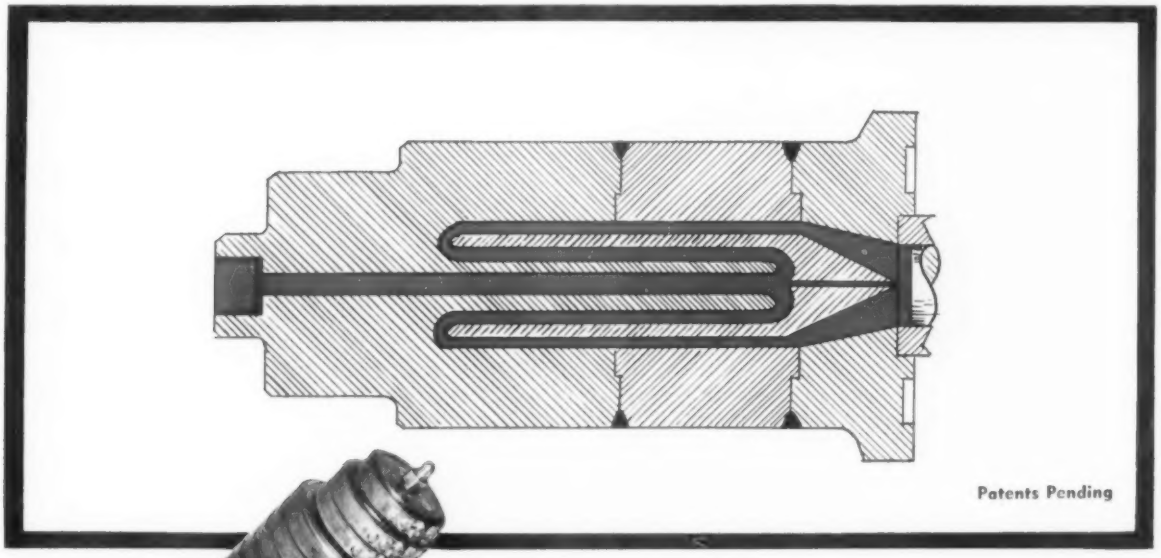

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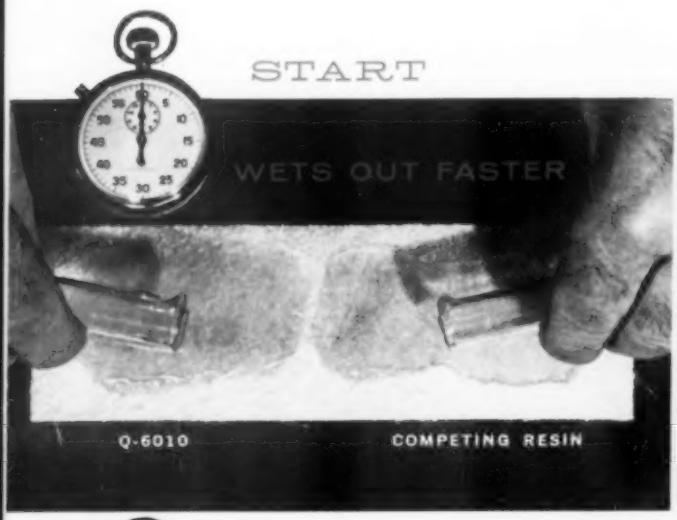

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Wet-out is hard to peg precisely, but here's a fast, simple way to compare your present resin with ADM's Q-6009 spray-up or Q-6010 and Q-6015 hand lay-up isophthalics. We'd like to send you samples so you can try it yourself.

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